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Germany and the Exposition There is plenty of room for a difference of opinion as to the expediency or desirability of a multiplicity of international expositions. Anyone can understand why the manufacturers of Germany, Great Britain or other nations should be lukewarm toward the Panama-Pacific Exposition in particular, but there are many classes of American manufacturers who must be writhing in anger—or amusement—over the constant repetition of the statement that German manufacturers are opposed to exhibiting at San Francisco for the reason that Americans might steal their designs and business secrets. This, as a reason for refusal to participate in the exposition, is repeated in a recent dispatch referring to the unfavorable action of the Association of Southwestern Manufacturers, of Mannheim, Germany. American machine-tool manufacturers who for years saw their designs systematically copied by German concerns can hardly take this objection seriously, unless it be on the theory that the Germans wish to borrow all the ideas they can get hold of from others while keeping their own to themselves. In several lines of light machinery manufactures, as well as in the heavier lines, the Germans have been apt and heavy borrowers, sometimes, it must be admitted, improving on our ideas in so far as strength and stability of construction are concerned. But if there is any balance of obligation in the exchange of ideas on the subject of machine design the Germans, it may be fairly said, are on the debit side; and there is certainly a fair prospect that if they come to San Francisco in 1915 they will learn at least as much from us as we shall learn from them.

Federal Control of Operation The report of the Interstate Commerce Commission on the North Haven accident and the agitation in Congress are probably forerunners of a definite movement toward a still stronger Federal control of railroad operation. The commission now has authority to investigate accidents and to make recommendations thereon, but it wants to be able to enforce its recommendations. Although the report of the commission criticises the New Haven company for inadequate signaling and its officials for ineffective supervision, it finds that the direct cause of the last collision was the failure of the employees to perform their duties properly. The signal system can be made better and the officials can exercise more rigid supervision, whether the employees like it or not, but if the rules are disobeyed after these remedies are applied the responsibility will still lie with the employees. If the commission is given the greater power which it seeks, it will either have to try to impose new or additional disciplinary measures on the trainmen through their employers or will itself have to assume some responsibility for the discipline of trainmen. Either plan involves a vast and dubious extension of governmental regulation. In addition to the rate-making authority, which it exercises with such potent influence for good or harm, the commission is charged with the monumental task of valuing the carriers. Whether it should be allowed still more authority to deal with complex and voluminous details of operation is a question that should be considered with infinite care by Congress before a final answer is given. With its present authority the commission can help, if it will, in the restoration of normal conditions of operation and mental balance of the men after the demoralization of a disaster. In this way it can be of great public service. It will fail to do this much good unless it so exercises its power, whether mandatory or recommendatory, as to command respect from both officials and the trainmen upon whom the safety of operation really rests.

Flood Situation in England The attention given in America to the subject of flood protection during the last half year makes of special interest the work done and urged along similar lines abroad. An account of reservoir systems in Germany was published in this journal recently. Judging by a paper read before the Society of Engineers by Mr. Reginald Brown, England, too, has flood problems to contend with. There is need, in Mr. Brown's judgment, of a comprehensive organization for dealing with the subject. Experiences in 1912 demonstrated not only that present measures were in many cases inadequate but also that the number of private acts of Parliament in force and the number of commissions having jurisdiction over some of the streams are extraordinary, making almost impossible a definition of their powers and rights. In consequence there is no uniform policy of procedure even on a given stream. Mr. Brown's proposed solution for the present mixed-up situation is the organization of a central body—a "rivers board"—to have charge not only of flood protection measures, but, in addition, to co-ordinate all work involving the use or control of the streams. The duties of the board would include supervision of proposals for drainage, water supply, prevention of pollution, straightening, prevention of restriction of waterway, removal of obstructions, and the collection of rainfall and flow records. This proposal is in line with the movement in the United States to place all water courses and supplies under conservation or State water-supply commissions. As to the wisdom of the course in the abstract there is no question. Moreover, the State plan is meeting with success here. Whether a similar scheme—as proposed by Mr. Brown—would prove as satisfactory in England, only those with thorough knowledge of local conditions can judge.

College Journalism With the opening of the colleges the editors of the college magazines return to their by-no-means-easy task. Judging by results, the wells of technical journalism are dry in most scientific schools. The fortunes of various papers show, however—as one might expect—that the fault was not with the college but rather with the college editors. It is evident that a student taking his full quota of work and doing justice to it does not find time heavy on his hands. If in addition to his studies and a reasonable social interest he essays to write for or edit a monthly or bimonthly magazine he must perform the latter duty between times and give it third or fourth rating in order of importance. Mindful of this fact, the judgment one might be inclined to pass must be softened. Nevertheless, because of more clearly defined ideals, longer experience or better organization—one or all of these—certain colleges are producing magazines that are a credit and that very likely have an influence upon the spirit of the college. A number of magazines could be cited as being above the average plane, but the "Cornell Civil Engineer" and the "Colorado School of Mines Magazine" are especially worthy of commendation. Both are "live" and both carry technical material of good quality. They recognize the demand for news and have developed personal columns that are probably the strongest factor in interesting the alumni. The Cornell journal lays more stress than most college papers do on excellence of illustration, while the Colorado magazine frequently runs editorials of high quality—that say things worth while and say them well. The development of a strong college paper is not the work of a year, or even of five. It must, first of all, appeal to the men in college. If they can be interested they will likely think favorably of the paper after graduation. Short, snappy articles, news columns that give "news" so far as a monthly can, and editorials that are not characterless will help to enlist undergraduate interest. Recently the "Technograph," published at the University of Illinois, ran two symposia by undergraduates, the subjects of which were within the range of the students' experience. The idea is a good one, for the young man who would dread the preparation of "an article" will not hesitate to write a paragraph expressing his views when he knows that others are to do likewise. There are so many advantages to the college and to the students from a well-conducted magazine that the college journal is worth a great deal more attention than it is receiving in many institutions.

Elephant Butte Dam Sand-blending of cement is a subject well worthy of general recognition, especially on work in remote locations, where high freight rates and long wagon hauls combine to make the cost of Portland cement excessive. Mr. Hill's article on page 368 describes the sand-cement plant at the Elephant Butte dam. A similar plant is in operation at Arrowrock, on the Boise project in Idaho. On the Los Angeles aqueduct the cement is reground with volcanic rock, comprising from 60 to 70 per cent of the whole, to form tufa cement. The advantages of blended cement have also been recognized abroad, and the product is now used in the construction of the Kaiser Wilhelm Canal in Germany. The mixture there adopted, however, is quite different from that in use in this country. The rock used is trass, a light-colored volcanic tufa resembling pozzuolana in composition and occurring on the lower Rhine. Only one part of this pulverized rock is used to two parts of Portland cement. As it is of vital importance to mix thoroughly the sand and cement before they enter the concrete mixer, precautions have been taken at Elephant Butte to obtain the required result. It is understood that the action of the sand binds chemically the surplus of free lime in the cement. Furthermore, there is under discussion for the concrete-mixing plant at Elephant Butte an interesting and well designed layout for the measuring hoppers. These are very large, as they serve 80-cu. yd. mixers, their gates being operated hydraulically. The fact that only two men are needed to operate each mixer speaks well for the economical arrangement of the plant.

An Unclassified Brand of Dishonesty

There is hardly an engineer who has been in practice for a long time who cannot tell one or more stories of the larceny of his ideas. Generally it is the story of one engineer using a design of a professional brother without giving the originator any credit. This practice generally is quite petty, and while preventing credit being given to whom it is due it does no material damage to the aggrieved party. Such stories come frequently to the attention of the Engineering Record, but for pure, unadulterated gall and double-dealing a recent instance stands out, as Elbert Hubbard has said, "like Mars at perihelion." In this case, however, a contractor has been the victim.

A manufacturing company erecting a new plant asked for bids for certain special equipment. In due course one of the bidders was invited, by phone, to call on the chief engineer of the company, was informed that his figure was satisfactory and that the work was to start very soon. Certain details, however, were awaiting the approval of the main office and the bidder would be notified when the approval was received. Immediately there began coming to the office of the contractor a procession of material men who had been informed that the contractor in question would get the work. Several days elapsed and upon being requested—again by phone—the contractor called on the engineer and was informed that the main office had decided that the equipment as designed was too expensive and that it was figuring on modifications looking to the cheapening of the work. Whereupon the contractor, an engineer by education and experience, volunteered the information that he could draw up a cheaper and equally satisfactory design. This suggestion was received with hearty approval, and within a few days the contractor submitted a design which the chief engineer affirmed was "just what we want," with further assurances that the work must be started immediately and rushed to completion. However, the main office had to be consulted regarding the suggested modification. Several weeks passed, with occasional conferences between contractor and chief engineer, followed by a complaint of the latter that the industrial-track layout, serving the equipment already mentioned, was unsatisfactory. Again the contractor could and did suggest a more economical design, following which was a period of several months interspersed by conferences, in all of which the contractor was led to believe that he would get the work, the main office always being responsible for some further delay.

Finally the contractor, losing patience, went to the plant, some distance from the city, and found the work on which he had bid half completed on his own designs by another contractor.

One might infer from this story that the manufacturing company is a small struggling organization, for a large company would hardly stoop to such larceny and double-dealing. Moody's Manual for 1912 says that the capitalization of the company is $3,000,000, that it has four plants, and further indicates that its directors are men of national standing, headed by a chairman who has been conspicuous as a leader in uplift and social movements. It is entirely probable that these men are not aware of the meanness in the organization below them; but such tactics should justly create conditions which eventually should come to their attention, for an organization of that kind deserves to lose public confidence. Nor does the fact that the contractor should not have waited for and expected the work without having a contract lessen the criticism which the manufacturing company deserves.

It can readily be foreseen under what conditions this company will find it necessary to carry on its construction in the future, for the knowledge of the double-dealing is bound to spread to material men and sub-contractors. The result will be that reputable firms will refuse to bid on future work, and the company will be forced to deal with second-grade contractors. In fact, there is now a goodly number of contractors who could not be persuaded under any circumstances to do work for the company in question.

Tactics of this sort may go unpunished for a long time, and even if the company succeeds in pulling through its contracts without lawsuits the bad name it gets among engineers and contractors who buy this corporation's products will result in a serious handicap to its sales organization. One cannot help feeling that there will be retribution, gradual if not sudden.

Some Features of Concrete-Bridge Design

The paper in the August number of the "Proceedings" of the American Society of Civil Engineers on some important features of concrete-bridge design is very timely and should elicit much valuable discussion. That there is wide divergence among designers on some of the features discussed is all the more reason for their full consideration. A review of the paper at length is not called for here, but it may be well to call attention to some of the points with a view of stimulating the discussion.

The authors state that the paper "is largely a plea for an arch consisting of two ribs, rather than one with a solid soffit; with narrow rather than wide ribs, and with deep ribs of I section rather than of rectangular section. It is also especially a plea for the three-hinged as compared with the fixed and two-hinged arches." The tendency of modern practice is undoubtedly toward the arch with a number of ribs rather than that with a solid soffit. Examination of the plans of many of the later arches with several ribs, however, cannot but raise doubt in the minds of many engineers as to the lateral strength of these ribs. It has taken years of experience in the construction of steel bridges to evolve the present satisfactory rules for bracing compression chords in a sidewise direction. No compression member is properly reduced in length unless it is held by bracing as deep as the member and rigidly attached to it; moreover, such bracing must be capable of transferring all lateral forces to the abutments of the bridge. When proper lateral support is provided much of the economy of ribs over the solid soffit disappears.

The use of the I section, instead of the rectangular, has not the sanction of many engineers. The excessive cost of the forms and the difficulties of making them tight and of spading the surfaces will in most cases offset the saving of concrete effected by the I section. Before adopting the rib design in preference to the solid soffit arch for short and medium-length fixed spans it should be remembered that the stresses due to rib shortening, temperature and shrinkage are proportional to the moment of inertia of the cross-section.

The claims for the three-hinged arch as to ease of stress analysis and adaptability to locations where the foundations are not absolutely unyielding are generally acknowledged. But the claim that temperature, shrinkage and rib shortening stresses are eliminated in the three-hinged arch is not fully realized, since there is a large frictional resistance at the hinges. From the standpoint of adequacy of design, therefore, hingeless arches, designed for temperature, rib shortening and shrinkage stresses, cannot be said to be inferior to the three-hinged arch in the design of which these stresses are neglected.

The superior appearance of the arch without hinges is conceded by the authors, but no great weight is attached to it. Yet this superior appearance, due to the gradual increase in the thickness of the arch ring from the crown to the skewbacks, is important wherever regard must be paid to architectural considerations.

In the comparisons of the cost of the several arches and their piers too much weight is given to the saving of concrete, for it is a well-recognized fact that a few yards of concrete more or less do not affect the cost of a structure as much as the character of the work itself.

The pier recommended by the authors, consisting of two legs instead of the solid rectangle, will hardly be accepted with readiness by the majority of engineers. Piers with two legs and cross-struts would require more formwork, fully as much excavation, and a higher grade of concrete for the same efficiency of structure as would the plain rectangular pier. It should not be forgotten, too, that the plain rectangular pier is generally of sufficient size to justify the use of cyclopean masonry, while the other type does not lend itself so well to the use of displacement stones.

There are other features that will undoubtedly receive consideration at the hands of members of the society, but these brief comments will serve to indicate some of the lines along which there should be much valuable discussion.

Interpreting Restricted Researches

Few problems of greater difficulty confront the engineer than the correct interpretation of investigations conducted on a small scale to throw light upon affairs in the large. This is only another way of saying that the application of laboratory data to outside matters of moment is no task for the amateur. Yet it is necessary to "try out" schemes, materials and combinations of equipment and to compare methods in miniature repeatedly in the main branches of engineering, and the ability to generalize correctly upon these restricted researches requires no mean technical judgment and sense of proportions. Here is a place where rough-and-ready decisions are about as useful as a shovel in a jewelry store, and the man who is called upon to make recommendations on the strength of data derived from limited investigations needs to open the windows of his mind on all sides.

The accuracy of the investigation, upon which much depends, is the first consideration. The limitations of the measuring instruments used, their comparison with standards, and the reliability of the observer cannot safely be overlooked. A small percentage off in a coal calorimeter may mean thousands of dollars lost to the purchaser of fuel, or, again, the dependence of the engineer upon unchecked switchboard instruments in studying feeder losses with a view toward remodeling a distributing system may lead to the installation of an unreasonably expensive layout. The approximate correctness of calculations from test data is of first importance, and the cost of checking these where far-reaching deductions depend upon them is a small percentage of the saving which such practice often insures. Within their scope the data secured on small-scale tests need to be of known reliability, and it should never be assumed that because an investigation is greatly limited slipshod or easy-going methods of conducting it are well enough.

In obtaining data on a small scale for larger application the investigator's most difficult problem is to determine how far the prevailing conditions are representative for multiplied use. Here enters the value of experienced judgment and the effectiveness of the scientific imagination. There are innumerable problems which can best be solved by service tests and an equally large number of matters which can be determined fairly within commercial limits by unit investigations. To discriminate properly between these classes of questions and the best methods of attacking them calls for broad knowledge, and especially for a grasp of physical science which the average man does not possess. Thus, the selection of a bearing metal may be made on the basis of elaborate life and heating tests on the road, or it may be made as the result of limited tests inside a laboratory, with an artificial mileage secured by an auxiliary motor drive. A fan motor may be selected for battleship ventilation on the showing of so-called "stand tests"—in the factory—or it may be chosen after subjecting it to service runs in the heated atmosphere of the boiler room. A pump may be specified for its efficiency showing in the shop test or forced to make good in the severe service of a contractor's plant. In some of these cases the laboratory will be able to answer the inquiry; in others, nothing but a practical knowledge of field conditions will enable one to reach a safe decision. So far as the important conditions of the field can be transferred without change to the laboratory, the small-scale investigation will meet the requirements; but as soon as the proportions of things begin to change the inductive value of small-scale tests shrinks rapidly toward zero.

The strength of a special arrangement of rivets might properly be determined in a testing machine, and an approximate idea of the durability of a storage battery under repeated shocks can doubtless be ascertained by placing a number of cells in an artificial jarring machine. But the selection of a new type of boiler grate or stoker on the performance of models would be a hazardous course to follow in the present status of combustion engineering. Similarly, the choice of a given design of electric motor for operating a municipal pumping plant on the strength of the low heating performance of a small motor of the same general type tested in the shop would be questionable practice, for the reason that the heat-radiating surface of one machine would be so different from that of the other that unless full data as to the heat-dissipating power and efficiency of the larger unit were available broad conclusions might easily be upset in service. A 15 per cent loss of energy in heat is one thing in a motor of 0.5-hp rating and quite another in a 50-hp machine, when the problem of getting rid of the heat is considered. The ability to see possible exceptions, differences and unusual factors is a very important qualification in the analysis of limited as well as of comprehensive investigations, and a small amount of thought should demonstrate to the man in charge of such work the necessity of taking a large view of small-scale experiments and making himself adopt a somewhat sceptical attitude in their conduct and interpretation in order to reach sound conclusions of technical and commercial reliability.

Recent Progress in Illuminating Engineering

The growth of special branches of engineering practice from small beginnings is nowhere better illustrated than in the field of modern scientific illumination, which is now developing at a pace that taxes even the abilities of the lighting expert. The scope of this work is one of its most striking characteristics, and it is well set forth in the report of the committee on progress of the Illuminating Engineering Society, presented last week at the Pittsburgh convention of that organization. It is difficult to cite any branch of applied science which is more rapidly getting out of its infancy or which is more responsive to the investigations of the laboratory. While it is true that within the past year few radical developments have been made in connection with light sources, great improvements have been made in the mechanical construction of existing systems, resulting in increased efficiency, and illumination has become the subject of study by physicists, oculists, architects, legislative bodies and others as never before.

One of the most notable advances is the announcement of a tungsten lamp giving an efficiency of 0.5 watt per candle-power, obtained through the use of a specially shaped filament in a bulb containing nitrogen or some other inert gas at a pressure of about 1 atmosphere. This gives little evidence of adaptability to low-powered illumination on account of the high current consumption required, but it promises to revolutionize incandescent street lighting in many cases and will bear watching. The tungsten lamp has become the standard incandescent electric lighting unit of the world for the most varied service applications, and recent improvements in its manufacture have extended its applications into lighting fields of entirely unsuspected practicability. It does not require much imagination to depict what the commercial production of the 10-watt, 100 to 130-volt lamp means to the domestic consumer of central-station service, or what free renewals and efficiencies running under 1.1 watts per candle-power are going to accomplish in the use of light on a somewhat larger scale. Few devices are rewarding the investigator more liberally, and the connection between the laboratory and the ultimate consumer has rarely been as close as here. It is characteristic of the age that it should not rest content with the striking gains in efficiency recorded in the last few years in tungsten lamps, but that efforts to secure still more efficient lighting should be multiplied on every side by the advent of this new resource.

Improvements in life, the elimination of defects, application of color screens, design of more convenient photometric apparatus, combination of vapor type with incandescent lamps to secure apparently daylight conditions, new methods of sealing, studies of resistance losses, production of special glassware, investigations in color photometry and many other activities are features of modern lighting practice in which advance is constantly being made. The flaming arc and the magnetite lamp are driving open and inclosed series and multiple arc lamps out of service, and an efficiency of 0.25 watt per candle-power is now available with a wide range of color values, while a consumption of 0.75 watt is claimed for the latest type of mercury vapor and tungsten combination, designed to simulate daylight. Announcement has also been made of a vapor lamp giving a white light with a specific consumption of only 0.16 watt per candle-power.

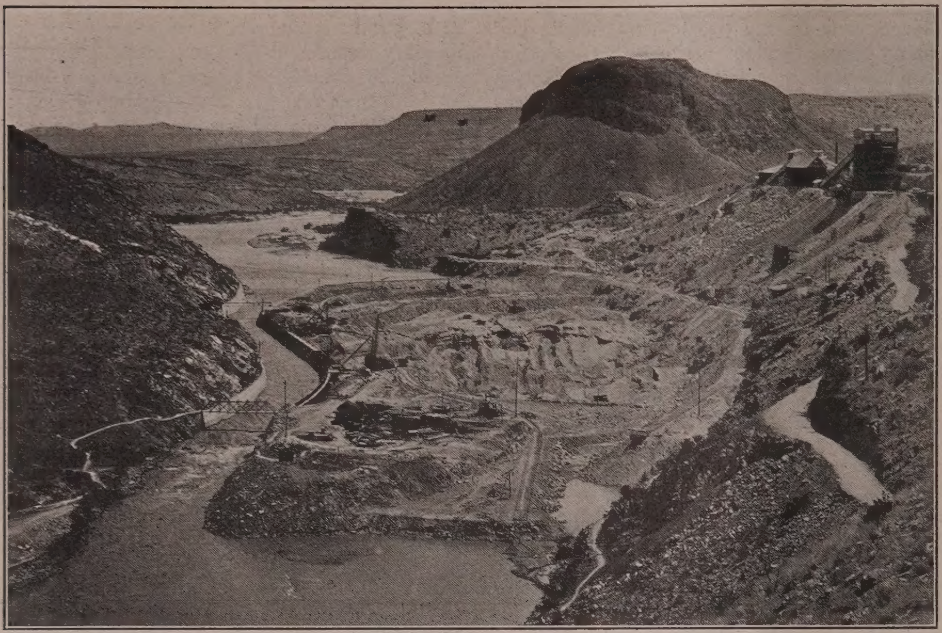
In the gas-lighting field the most important development in the past year has been the introduction of a high-powered single-mantle inverted lamp, filling a place between the old small unit and the multiple mantle lamp, and giving from 180 to 225 mean spherical candles, according to the gas used and the pressure available. The artificial silk mantle, with its durability, strength and immediate application on the burner, is also coming into rapid use. Little advance has been made in the direction of "cold-light" production, but the development of standards, advances in ophthalmology—particularly in the study of school-house and other assembly lighting—work of the national societies, progress in indirect-unit train-lighting, fixture development and advances both artistic and economical in ornamental lighting—all bear witness to a sound and inclusive growth in this most important and far-reaching specialty.

Traffic Regulations and Street Accidents in London

The increase in the number of fatal accidents on the streets of London from 155 in 1904 to 537 in 1912, together with the doubling of the non-fatal accidents in the same period, indicates the seriousness of the traffic problem in London. One would naturally associate this increase with greater congestion, but a recent report of a select committee of the House of Commons indicates that such is not the case.

Congestion is now less acute than formerly. This is due to the excellence of the traffic-regulation methods. The committee considers the various factors affecting accidents and makes a number of observations that are at variance with common belief. For example, it is claimed that speed is not a serious element in the cause of accidents. In only six fatal cases in 1912 was the legal limit exceeded, and in three of these the culprits themselves were the victims. The police also seem to have recognized this, for they do not appear to favor the further limiting of speed, which for tramcars is 16 miles per hour and omnibuses 12 miles. In practice both types of vehicles probably exceed these limits under favorable conditions. One decidedly interesting observation of the committee is that 81 per cent of the accidents occasioned by power-driven vehicles occurred where there are no refuges within 100 yd., while 84 per cent of those attributed to horse-drawn vehicles happened in similar localities. In spite of this evidence, however, the committee recommends that speed registers should be fitted both to tramcars and to motor buses. Weather conditions, the committee finds, are seldom a contributory cause of accidents, while bad light has little influence, since accidents are not more common in ill-lighted than in well-lighted streets.

The main cause appears to be carelessness both on the part of drivers and of the public. To improve conditions the committee recommends that motor-driven vehicles be brought under closer control, that speed limits be set for omnibuses and other heavy traffic, that more stringent regulations be enforced by the police and that special measures be taken to warn school children and their parents of street dangers.



View of Site of Dam Looking North, Showing Diversion Flume

Elephant Butte Dam Construction

Preliminary Work and Construction Plant, which Includes Three 80-Cubic Foot Concrete Mixers and Hydraulically Operated Measuring Hoppers

By Louis C. Hill, Supervising Engineer, U. S. Reclamation Service, Los Angeles

The Rio Grande project of the U. S. Reclamation Service comprises from 180,000 to 200,000 acres of rich alluvial land, stretching along the Rio Grande from a point about 120 miles above El Paso to a point about 30 miles below. Part of this land has been in cultivation for several hundred years. The diversion from the river for all this time was made by the crudest kind of brush and rock dams. The result of this system of irrigation was a most uncertain water supply, the floods usually taking out the dams and making it impossible to replace them until the water had receded.

About twenty-five years ago the headworks of the canal at El Paso, taking water out for the Juarez, Mexico, district, were destroyed, and a more or less permanent dam was built at the Hart mill. As the irrigated area in Colorado and northern New Mexico was gradually enlarged the demand for water from the headwaters of the Rio Grande in Colorado and northern New Mexico increased and the low-water flow of the river gradually diminished. Complaints were made by the users lower down the river, both on the American and Mexican side of the line, of the result of this diversion. These complaints culminated in a commission being appointed and a treaty being signed between Mexico and the United States, whereby the United States was to furnish to Mexico 60,000 acre-ft. a year at the Mexican dam at El Paso in lieu of all claims for water or for damages.

Congress appropriated $1,000,000 as the general Government's contribution to build a reservoir which would satisfy this claim.

After the Reclamation act was passed strong pressure was brought to bear to include as one of the projects to be considered the irrigation of land along the Rio Grande. The project was finally approved, after many preliminary investigations had been made as to the probable water supply, the amount of silt probably carried by the stream, the available land, and all the conditions which would affect the success of the undertaking. The storage dam, which was described briefly in the Engineering Record of May 17, page 557, was finally located at a point near Elephant Butte, 12 miles west of Engle, a small town on the Santa Fé Railroad about 110 miles north of El Paso.

RIVER CONDITIONS

The runoff of the Rio Grande varies widely from year to year. It was necessary, therefore, in order to utilize the water to the best advantage, to build a reservoir large enough to carry over an excess supply which can be distributed over several low years and at the same time provide a large storage capacity to dispose of the silt carried by this muddy stream. The amount of silt carried varies year by year both in per cent and in quantity. It may average as much as 15,000 acre-ft. per year. The height of the crest of the spillway of the dam was finally determined as 193 ft. above low water in the river. This would create a reservoir about 40 miles long and having a capacity of 2,600,000 acre-ft.

Appreciating the certainty that the reservoir will gradually fill up with silt, the dam was located in a place where its height may readily be increased up to at least 40 ft. above the present elevation. This would add additional capacity to the reservoir, at least equal to the present designed capacity. During 1909 surveys were completed for making a contour map of the reservoir, and in 1910 drilling was commenced in the bed of the river to determine the character of the foundations and the distance to bed rock.

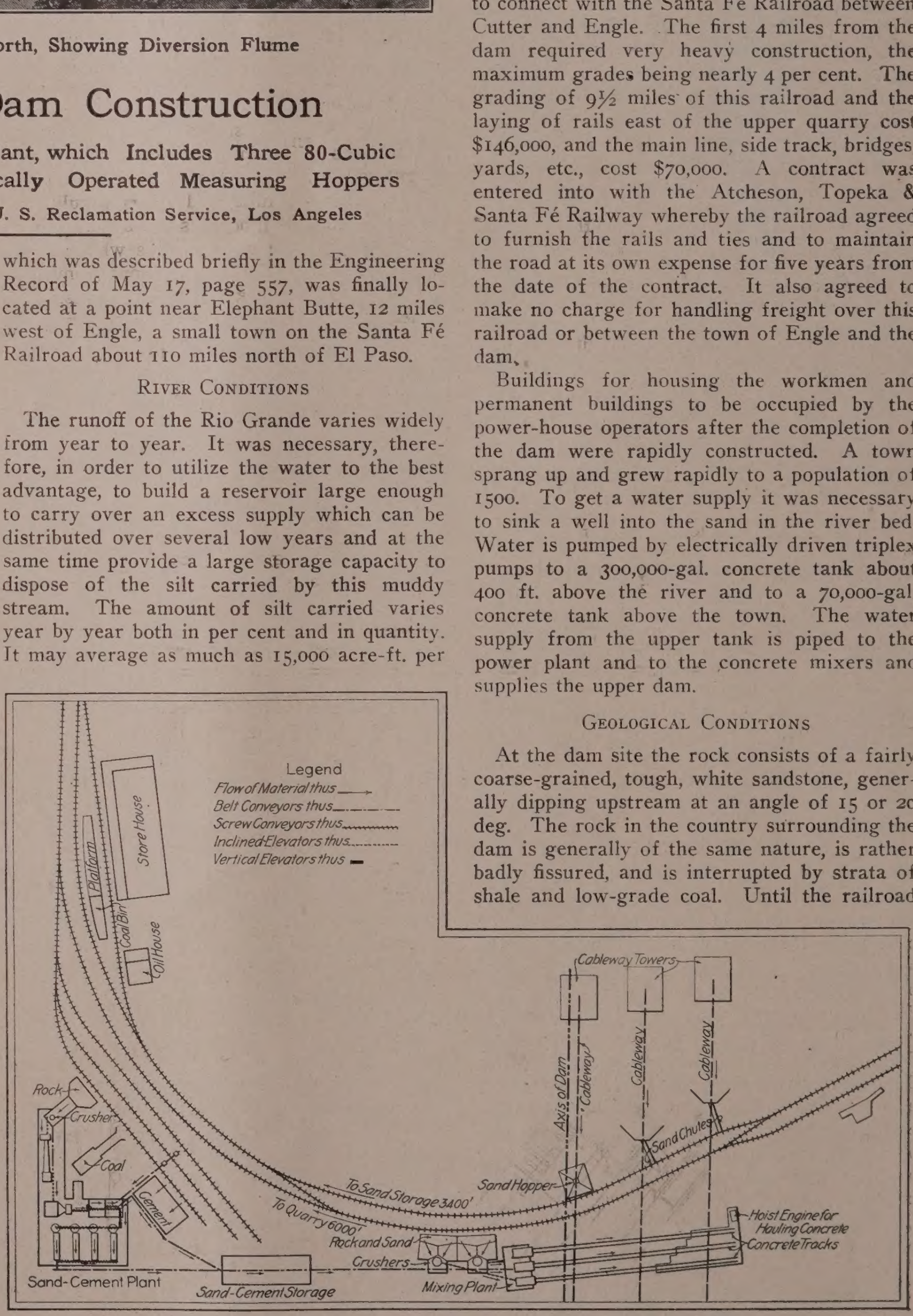
RAILROAD

On account of the small allotment, work could not be pushed rapidly for several years, but in 1911, when more money was available, the forces were materially increased and work was begun on the preliminary structures. A railroad line was surveyed from the dam site to connect with the Santa Fé Railroad between Cutter and Engle. The first 4 miles from the dam required very heavy construction, the maximum grades being nearly 4 per cent. The grading of 9½ miles of this railroad and the laying of rails east of the upper quarry cost $146,000, and the main line, side track, bridges, yards, etc., cost $70,000. A contract was entered into with the Atcheson, Topeka & Santa Fé Railway whereby the railroad agreed to furnish the rails and ties and to maintain the road at its own expense for five years from the date of the contract. It also agreed to make no charge for handling freight over this railroad or between the town of Engle and the dam.

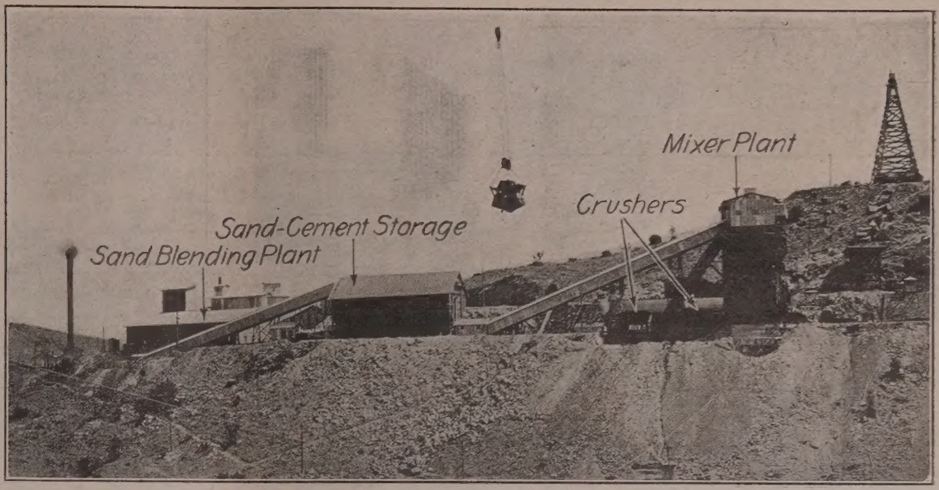
Buildings for housing the workmen and permanent buildings to be occupied by the power-house operators after the completion of the dam were rapidly constructed. A town sprang up and grew rapidly to a population of 1500. To get a water supply it was necessary to sink a well into the sand in the river bed. Water is pumped by electrically driven triplex pumps to a 300,000-gal. concrete tank about 400 ft. above the river and to a 70,000-gal. concrete tank above the town. The water supply from the upper tank is piped to the power plant and to the concrete mixers and supplies the upper dam.

GEOLOGICAL CONDITIONS

At the dam site the rock consists of a fairly coarse-grained, tough, white sandstone, generally dipping upstream at an angle of 15 or 20 deg. The rock in the country surrounding the dam is generally of the same nature, is rather badly fissured, and is interrupted by strata of shale and low-grade coal. Until the railroad



Plan of the Construction Plant for the Elephant Butte Dam



Arrangement of Sand-Blending Plant, Storage, Crushers and Mixers

was constructed, opening up some apparently good rock by deep cuts, it seemed probable that it would be necessary to construct the dam entirely of concrete because of the impossibility of finding large rocks of suitable nature to incorporate in the dam.

Two quarries have been opened up—one containing probably 100,000 yd. on the west side of Ash Canyon and the other about ¼ mile further away from the dam on the east side of Ash Canyon, and alongside the railroad. The character of this rock is uncertain, so that in quarrying there will be a large amount of waste, adding materially to the cost of the structure. In quarry 2 the rock rises very rapidly some 200 or 300 ft. higher than the tracks, so that there is ample rock in this quarry; but it is even yet doubtful whether there will be any great amount of large rock which can be incorporated in the masonry.

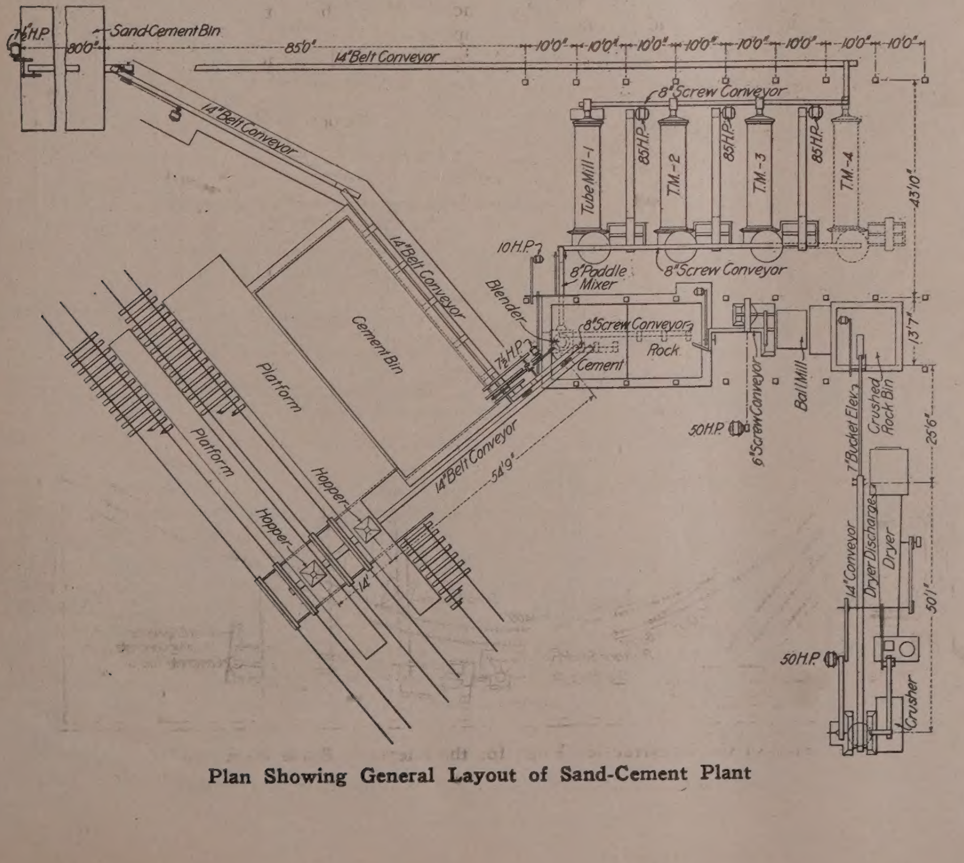
Drilling at the dam site showed that rock existed at a depth of 60 ft., as indicated by the cross-section. Although this is a silt-bearing river, the material in the drill holes indicated that the sand necessary for construction could readily be obtained from the bed of the stream. The rock was of such a nature that it did not make a satisfactory sand when crushed, and it was thought that it might be necessary to get all the material necessary for crushing to sand from a lava butte about ¼ mile from the dam.

Since excavation has started sand of a most excellent quality has been found to exist only a short distance under the surface of the river bed, and the excess above the amount which can be immediately delivered to the mixers is being carried to the yard and stored for future use.

Between the quarries and the dam site there is a double-track railroad, over which all the rock for use in the dam will be transported from the quarries and over which the sand will be transported to the storage pile, and later taken back to the mixing plant.

The maximum recorded flood in the river is about 30,000 sec.-ft. With this one exception there has been no flood much, if any, in excess of 20,000 sec.-ft.

In order to divert water during construction, two methods were studied—one by means of a large tunnel carrying the water around the works and the other by building a large flume on the west side of the river, founding it on rock and carrying it through the dam as a part of the masonry. The quality of the rock and the location of the dam made the latter method seem less expensive and considerably safer, and was accordingly adopted. Where flume excavation crossed the dam site it disclosed a number of faults, and a very peculiar fold. No diamond drill borings had been made as far back from the river as this when the flume was located, as all the indications seemed to show that the rock exposed on the hillside continued at a uniform slope to the rock in the bottom. This proved to be erroneous, and it was necessary in order to put in that part of the dam through which the flume passed to excavate about 50 or 55 ft. through rock and shale before solid rock was reached.



Plan Showing General Layout of Sand-Cement Plant

Construction Machinery

While this preparatory work was going on orders had been placed for construction machinery. Three Lidgerwood cableways of 8 tons normal capacity were purchased. The cables are 2¼ in. in diameter, of the locked-strand type and of about 1400-ft. span. Two are made by the Trenton Iron Works and one by the A. Leschen & Sons Company. The hoisting speed is 200 ft. a minute and the traveling speed 800 ft. a minute. It was not considered advisable, on account of the relatively short haul, to increase the speed much above this. Each cableway is operated by a 300-hp., 2200-volt motor. The general layout of the cableways, with reference to the dam at its location in the canyon, is shown in the accompanying drawing.

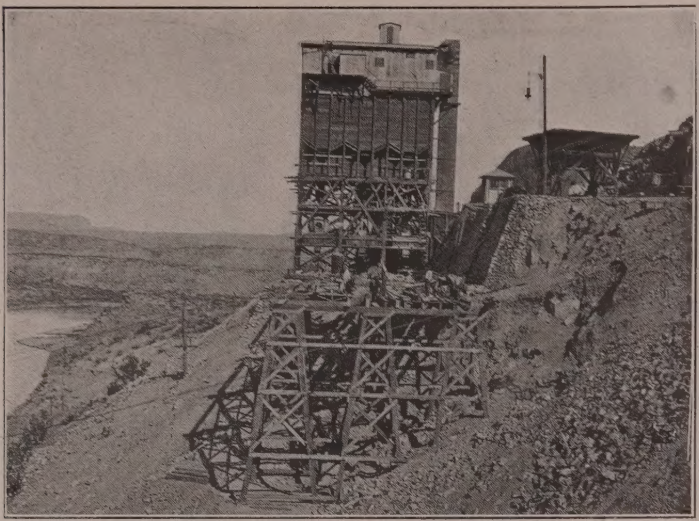
For excavating the sand and gravel from the river 3-cu. yd. Andresen-Evans buckets were purchased, and have been successfully used since excavation was begun. Some trouble was found at first in the opening mechanism. With some changes made in the shops at Elephant Butte this trouble was eliminated and the efficiency of the buckets has been greatly increased. The cables are about 380 ft. above the bottom of the excavation.

The power for operating the construction plant is furnished by a steam turbine plant located a short distance from the dam. It consists of three 500-kw turbo-generator sets furnishing 60-cycle current at 2200 volts. The current is distributed at this voltage and used directly without transformation by the cableways and some of the large motors. The voltage is stepped down for the pump motors and for the smaller motors located in various places. Two small turbine-driven, direct-current dynamos, each of sufficient capacity to handle the three main units, furnish the exciting current. Coal is delivered by the Atchison, Topeka & Santa Fé Railway in bottom dump cars, when possible, and passed through a coal breaker to steel storage bins located just above the automatic chain-grate stokers. The furnace is of the modified Dutch oven type. The four boilers are of the Erie vertical water-tube type, in batteries of two each.

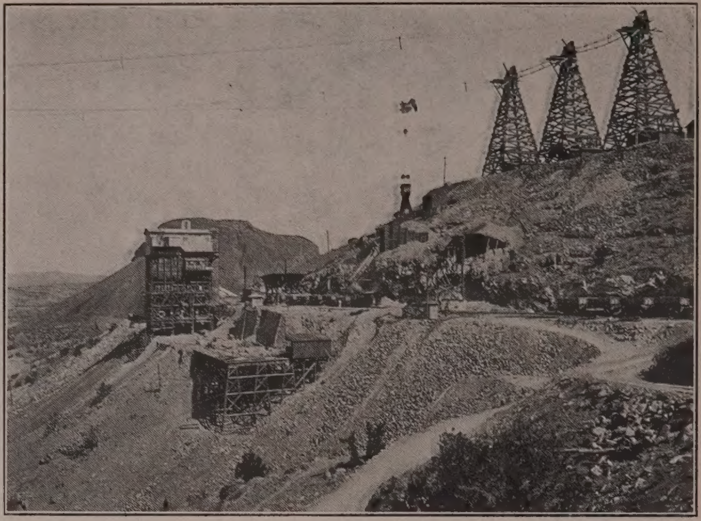
The turbines showed on test an average consumption of about 20 lb. of coal per kilowatt-hour.

Owing to the very variable load during the early stages of the work the coal consumption has been rather high. Coal is purchased under standard Government specifications and each car load is weighed and tested.

It was anticipated that a large amount of water would probably be encountered in excavating for the foundations, and provision was made for handling it with direct-connected centrifugal pumps, driven by electric motors. The size of the power plant was also somewhat increased to allow for this contingency. Fortunately the amount of water



Mixer Plant with Trestle for Concrete-Distributing Tracks



Cable Towers and Their Relation to the Mixer Plant

encountered has been relatively very small. It is necessary to pump only about 1200 gal. a minute to keep the pit clear of water. The present pit is about 85 ft. deep, 200 ft. or more wide and 400 to 500 ft. long.

The cost, including overhead charge, of this power plant complete with coal-handling, ash-handling, water-purifying and cooling tower systems, was $136,500.

Sand-Cement Plant

Experience at Roosevelt in constructing and operating a plant for furnishing cement used in building the dam had demonstrated the possibility of making a very material saving at other places. The net saving at the Roosevelt dam above the lowest bid price was nearly $600,000. There was material available near Elephant Butte for making cement, but the shorter haul and the lower price for cement made the saving by constructing a cement plant too small to justify the expenditure. Experiments were begun early and continued for a long time to determine the feasibility of manufacturing sand-cement from the material found at Elephant Butte which would be suitable and safe to use in constructing the dam. Estimates were made on the probable cost of producing this sand-cement, and it was finally decided that it would result in a saving of more than $200,000 to build the dam from sand-cement, and that the results obtained, both as to strength and density, would be in favor of the sand-cement. Accordingly, a sand-cement plant was designed by Mr. R. R. Coghlan, who was manager of the plant at Roosevelt, assisted by Mr. O. L. McIntyre and Mr. L. J. Charles. The machinery for this plant was purchased, and the plant was completed ready for operation on March 1, 1913.

Rock from the sandstone quarry is delivered to a gyratory crusher. The product of this crusher goes to the bin above the ball mill either directly or through a rotary dryer, provided the rock contains enough moisture to make it necessary. The ball-mill product goes to the ground-rock bins. The cement is delivered by the railroad in cars which are spotted opposite hoppers and the sacks emptied into the hoppers. From the hoppers the cement is automatically conveyed to the Portland cement storage bin next to the ground-rock bin. From these bins the cement and ground sandstone are delivered by screw conveyors to an automatic mixer, which can be so set as to make the product delivered by it carry any desired proportion of sand to cement.

This product is carried by a mixing conveyor to a long conveyor running above the hoppers feeding the four tube mills. Gates may be so adjusted that each mill gets an equal feed.

The product from the tube mills is delivered into a long conveyor running along the end of and serving all four mills. This conveyor delivers its product on an inclined belt conveyor, which carries the sand-cement to the top of the storage bins. The automatic tripper delivers the product to any desired bin.

Gates are placed in the bottom of the storage bins discharging on a belt conveyor, which runs under all the bins and at the south end rises at an inclination sufficient to deliver the product to the small cement storage bin above the mixers.

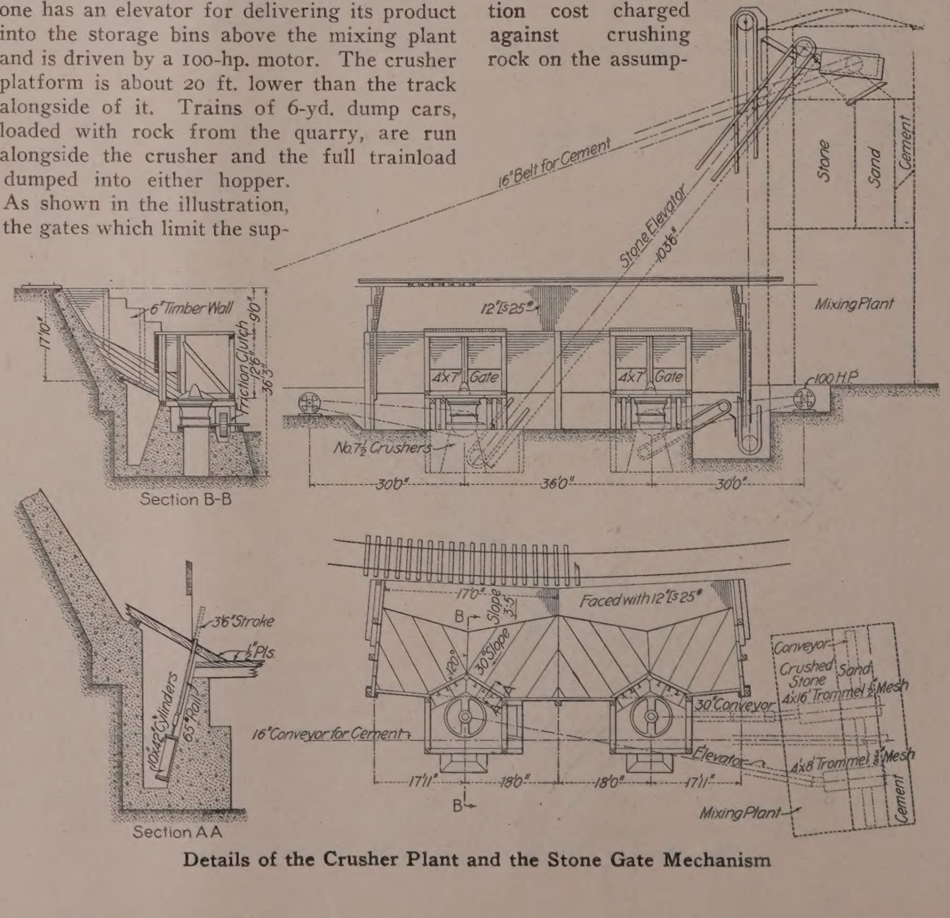
The cost to date of this plant, including buildings, machinery and overhead charges, is about $56,000.

Crushing Plant

The crusher plant consists of two No. 7½ Symes gyratory crushers, each having a capacity of from 100 to 150 tons per hour. Each one has an elevator for delivering its product into the storage bins above the mixing plant and is driven by a 100-hp. motor. The crusher platform is about 20 ft. lower than the track alongside of it. Trains of 6-yd. dump cars, loaded with rock from the quarry, are run alongside the crusher and the full trainload dumped into either hopper. As shown in the illustration, the gates which limit the supply to the crusher consist of rails handled by plungers moving up like fingers to prevent an excess amount of rock pouring into the crushers when dumped by the train from the quarry.

The product from one of these crushers is delivered into an inclined bucket conveyor, of a capacity of 100 to 140 tons per hour, and the other is delivered into a platform conveyor of the same capacity, which in turn delivers it to a vertical elevator. The product from each one of these crushers is delivered into a drum-screen, the fines passing into the sand bin and the overs into the rock bin. Under normal conditions either one of these crushers will furnish the rock to the full capacity of the rest of the plant.

Over each crusher has been built a house to protect the men operating the crushers. It will require two men to feed each crusher when operating under normal conditions. The total cost of this crushing plant, including bins completely installed ready for operation, is $31,500. The depreciation cost charged against crushing rock on the assump-

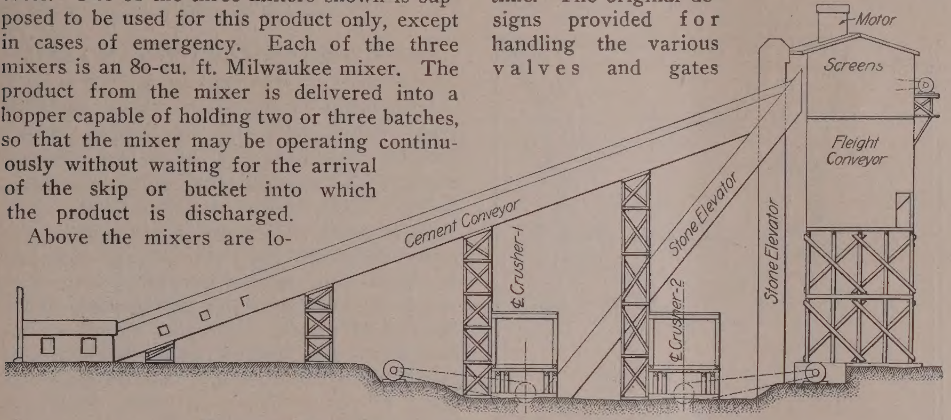


Details of the Crusher Plant and the Stone Gate Mechanism tion that the plant is scrapped when the job is finished, is 10.6 cents a yard and the labor cost is approximately 12 cents a yard.

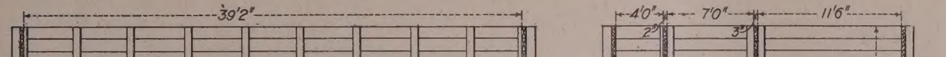
As soon as the plant is operating at full capacity this labor cost will be materially reduced, as it will take practically no more labor to handle a greatly increased output.

Concrete Mixing Plant

One of the accompanying illustrations shows the general layout of the mixing plant. Specifications require that the upstream 10 ft. of the dam be made of a different mixture from the rest of the dam—a mixture which is intended to be so proportioned as to give the greatest possible density and imperviousness to the concrete. One of the three mixers shown is supposed to be used for this product only, except in cases of emergency. Each of the three mixers is an 80-cu. ft. Milwaukee mixer. The product from the mixer is delivered into a hopper capable of holding two or three batches, so that the mixer may be operating continuously without waiting for the arrival of the skip or bucket into which the product is discharged. Above the mixers are located three measuring hoppers, shaped something like truncated pyramids, connected by a rectangular piece. The rectangular piece is so arranged that one part of it telescopes on the other, so that the capacity of the measuring hopper can be changed by loosening or tightening four bolts. The gates for cutting off connection with the bins and for closing the bottom of the measuring hoppers are both parts of cylinders. An automatic, hydraulically operated, interlocking mechanism is so arranged as to perform all the functions of opening the gates to the bins and closing; opening the discharge from the measuring hoppers, and closing; opening the discharge from the receiving hopper just above the mixer into the mixer—the operator simply determining the time at which the operation shall start.



Elevation of Crusher and Mixer Plants and Conveyors



Sectional Elevation of Mixer Plant with Measuring Chutes

The amount of water furnished to the mixer for each batch is determined by a setting of a siphon attachment to the supply tank, which permits a fixed amount of water to be discharged each time the siphon is started. The amount that can be discharged each time can be varied at will by changing the setting.

The measuring hoppers are so large that it is practically impossible to operate them by hand without considerable expense and loss of time. The original designs provided for handling the various valves and gates hydraulically, and the temporary use before the hydraulic apparatus was installed soon demonstrated its desirability. It has been in operation now for several months and is working satisfactorily.

As shown on the general layout, three tracks run from the mixing plant at right angles to and beyond the cableways. At the opposite end from the mixing plant there is located a three-drum hoist, which handles a car on each one of the tracks. One mixer, therefore, can serve any cableway, and only one man is required to handle the complete operation. The number of hookers-on depends of course on the number of mixers in operation and the rapidity with which it is desired to put in concrete. Two men on each mixer will probably give the greatest economy when uniformity of the product is taken into consideration. It is possible, however, for one man to handle the mixer.

The total cost of this mixing plant, including all machinery, storage bins, elevators (not considering the crushing plant) and concrete haulage system is $57,800. The depreciation cost is 13 cents per cubic yard of concrete, and the labor cost will be about 8 cents per cubic yard with plant in full operation. At the present time, operating at only a small fraction of its capacity, the entire cost for labor is 14 cents per yard.

The details of the automatic interlocking arrangement have been very well worked out.

One of the drawings shows the general layout of the construction plant, with the exception of the tail towers of the cableway, which are on the opposite side of the river.

Quarry 1 is located just above Ash Creek Canyon Bridge. The railroad ran along the side of this canyon, and in building this there was developed a fairly good sandstone quarry, some 500 or 600 ft. long. The good rock excavated at this quarry was used in the dam, and the waste was so disposed of as to widen the road bed, so that a double track could be laid. The side slopes of the canyon are probably 50 deg., so that the working face of this quarry is very high. The road is single-tracked from this quarry to where No. 2 quarry is reached, where a branch line leaves the main line. No. 2 quarry showed big possibilities before it was opened up, but further development has indicated that it will hardly furnish more than about 100,000 cu. yd. of good rock.

From the west end of Ash Creek canyon bridge a double-track railway extends by the dam site. Where this road crosses Spring Creek canyon on a high trestle a double set of rails is used, making a switch unnecessary; although, of course, trains cannot pass on the bridge.

Derricks

The handling of material for construction of the dam and part of the excavation not handled by the grab buckets will be done by stiffleg derricks of 8 tons capacity, operated by 440-volt, three-phase induction motors. The derricks in the quarry are guyed derricks of the same capacity. They were manufactured by the American Hoist & Derrick Company and have given satisfactory service.

A vertical section through the deposit of sand in the bed of the river shows streaks composed of various classes of sand, coarse and fine, alternating in layers. The method of excavating is such that this sand is most thoroughly mixed. The grab buckets pick up the sand from the bottom, and after they have dug a trench drag scrapers operated by electric hoists are used to drag in the material outside the reach of the buckets. After being picked up by the grab buckets the sand is carried to the east side and dumped into hopper bins, from which it is loaded into cars. The cars then carry the larger part of this sand to the storage pile, where it is dumped and again mixed. Later this sand will be picked up by grab buckets, loaded into cars, brought back to the mixing plant, dumped into the sand hopper, and elevated into the bins above the mixing plant. The sand will, therefore, be of uniform quality when it reaches the mixers. About 20 per cent of the sand will go to the mixer bins directly without going to the storage pile.

Sinking Second Section of Harlem River Tunnel Tubes

The second section of the steel lining for the Lexington Avenue Subway tunnel under the Harlem River in New York City was successfully sunk to position, 60 ft. below the surface of the water, on the afternoon of Sept. 26 by exactly the same method that was used for sinking the first section on Aug. 29, as described and illustrated in the Engineering Record of Sept. 13, page 284.

Like the other section, this one consisted of four flattened steel tubes 19 ft. in diameter and 220 ft. long, connected by vertical transverse steel diaphragms and exterior wooden sheeting, equipped with the same pair of temporary auxiliary 10½-ft. air cylinders 65 ft. long, and fitted with erection bulkheads and valves. The entire mass, weighing in air nearly 800 tons, was floated to the site, moored in approximate position, and sunk to the bottom of the river by the addition of about 7000 tons of water, which produced a slight excess over the buoyancy of the closed tubes, thus giving a small positive weight, which was easily lowered and controlled by a pair of floating derricks and hoisting engines, by which the final adjustment of the tubes in position on the river bottom was effected.

The plant and method employed were the same as on the previous occasion, and accomplished the same result, except that, owing to a slight modification of the valves, the sinking was more rapid. The great mass was at all times under perfect control and was lowered steadily and gently to the bottom of the river without plunging. The adjustment and the connection to the first section were accomplished with ease, rapidity and accuracy. Three similar sections remain to be sunk in the same manner to complete the tunnel.

So much professional interest and appreciation of the successful sinking of the first section of the tube had been shown that the Arthur McMullen & Hoff Company, contractor for the construction of the tunnel and adjacent section of the subway, invited more than 100 prominent engineers and contractors to witness the operation.

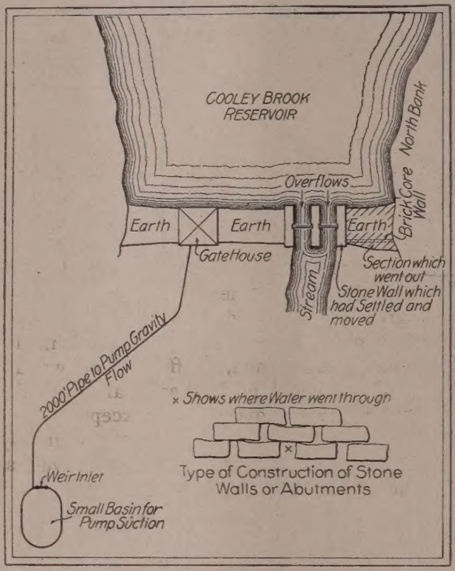
Scuttling Valves Opened

At 12:30 p. m., after the guests had been entertained at luncheon by the contractors, the scuttling valves were opened to admit water for sinking the tubes, and an hour later the tubes were fully submerged. The air cylinders were entirely submerged at 2:40 p. m., leaving an unbalanced weight of probably 3 tons, which was handled by the two derricks. The tubes descended the remaining 20 ft. in seven minutes.

They were at first landed on the sills prepared in the bottom of the trench in a position about 5 ft. from the end of the first section, and notwithstanding the tidal force encountered were within about 3 ft. of alignment. They were pulled into the required position by four guy lines operated by the hoisting engines, the location being exactly checked by instrumental observation on the steel masts attached to the tubes and projecting vertically above the surface of the water.

The final adjustments were effected by two divers, who inserted a pair of long 5-in. horizontal pilot pins, connecting the adjacent ends of the two sections. These pins, which were illustrated in this journal Sept. 13, page 285, were locked into fixed bearings in castings riveted to the upper parts of the outer tubes in the second section, and their tapered projecting ends were entered in the conical openings of corresponding castings on the ends of the first-section tubes. As the pins passed through the coned castings they centered the tubes in the same alignment, and after the ends of the tubes were within ¼-in. of each other the pilot pins were locked in position by tapered keys driven through them in contact with the coned castings. The adjustment was completed at 4.30 p. m., exactly 4 hours after the beginning of sinking operations.

This operation completed the adjustment and was immediately followed by making the splice joints between the two sections. This was effected by inserting numerous longitudinal ⅞-in. bolts about 9 in. long through the outstanding legs of circular flange angles on the adjacent ends of the tunnel tubes and screwing them up tightly by divers to draw the sections together all around the circumference.


COOLEY BROOK RESERVOIR
Overflows
North Bank
Brick Core Wall
Earth
Earth
Earth
GateHouse
Section which went out
Stone Wall which had Settled and moved
Stream
2000' Pipe to Pump Gravity Flow
× Shows where Water went through
Type of Construction of Stone Walls or Abutments
Weir Inlet
Small Basin for Pump Suction

Sketch Plan of Cooley Brook Dam which Washed Out

Thus the two tube sections were made continuous with only a very thin joint which will not admit more water than can easily be controlled by moderate pumping when the tubes are unwatered and entered after all of them have been sunk. At this stage of operations these joints will be completed by the addition of circular inside cover plates bolted to the flanges of Z-bars riveted to the inner faces of the tubes opposite the exterior bolted flanges. It is hoped that the last section will be joined within a few months. Then the tubes will be ready to receive the inner concrete lining, which will complete the tunnel.

The assembling of the 645 tons of steel in this section of the tubes was begun at the contractors' yard on Aug. 3 and was completed in five weeks, as described on page 390 of this issue. After its removal from the assembling skids, operations were commenced on the fabrication of the next section, but the sinking of the latter will be somewhat delayed until the rock in the dredged trench is removed.

The section was sunk by a force of thirty-five men, all of whom, except the two divers, were working in the open air and were subjected to no danger or hardship—conditions very different from those prevailing in tunnel excavation or compressed-air work, which the contractors believe would undoubtedly have been much more prolonged, dangerous and expensive than the method employed.

Work will immediately be commenced of inclosing this steel section with a 24 x 26-ft. mass of concrete deposited through tremies in the fourteen 550-yd. pockets formed to receive and protect it by the tube diaphragms and the longitudinal sheeting. This concrete will form the main tunnel structure, distributing the load over the bottom of the wide trench and protecting the steel lining. It has already been completed for the section previously sunk.

Work is being executed under the direction of the Public Service Commission, of which Mr. Alfred Craven is chief engineer; Mr. Robert Ridgway, engineer of subway construction, and Mr. C. V. V. Powers, division engineer. The Arthur McMullen & Hoff Company is the contractor, for whom Mr. N. R. Melvin is superintendent in charge.

Cooley Brook Dam Washed Out

Water stored in the Cooley Brook reservoir, which supplies the town of Chicopee, Mass., near Springfield, last week found an opening through the earth dam across the stream, washed out a section of embankment 25 ft. wide and left the storage basin empty. For many hours the town was without adequate fire protection until an emergency connection was made with the water-supply mains of the Springfield system. That the failure of the dam was due to lack of suitable foundation at the time the dam was built, some 20 years ago, seems to be the opinion of those who have made an inspection of the site since the washout occurred. It is believed that the failure of the embankment had been foreshadowed for several months by the settlement of one of the masonry walls of the overflow. Leakage was not confined to the point where the dam gave way, it is said, but was excessive all about and under the overflow and core wall, and also below the planking which forms the bottom of the overflow.

The high-service-water system of Chicopee is secured from the normal flow of Cooley Brook, a small stream in the northeastern portion of the town. This stream has no considerable watershed but is in the gravelly and sandy plateau which is underlaid by the brick clay which outcrops all along the Connecticut River. The flow of the stream is largely made up of the flow from springs, which are in reality the outlets of the large storage capacity of the sandy plateau. The flow was well sustained and the necessity or possibility for storage is small with the present use of the city.

In 1893 there was constructed across Cooley Brook a dam designed to raise the water about 6 ft., thus diverting the flow of the stream into a brick gate house and furnishing sufficient head to force the water to a small basin about 2000 ft. downstream. From the basin water was pumped to a standpipe to furnish the pressure to the city.

The sides and bottom of the site of this dam were of a rather fine sand, containing practically no binding qualities, and the dam as constructed was apparently of this material mixed with such loam as could be obtained.

Character of Dam

The dam for the purpose of this description can be divided into three parts, all similarly constructed of earth with a single-course brick core wall which did not extend down into the substrata. Each of these sections are from 20 to 25 ft. in length. The south section is separated from the central section by a small brick gate house, into which the flow from the small ponded area is diverted to the pumping station. The central section is separated from the north section by the overflow. It was the north section which went out.

The overflow is constructed by building through the dam and parallel with the course of the stream three walls of cut stone, each of a central width of about 16 in., carried to the height of the dam. These three walls were about 6 ft. distant from one another, thus leaving two spillways, each about 6 ft. long. For these spillways iron channels were fastened to the masonry and in these channels were set planks or flashboards. By removing these planks the small reservoir could be entirely drained. Between the foundation of these three walls and the north bank of the stream was the section which gave way.

Water Seepage

As a foundation for the walls, planks were laid down not more than 6 ft. below the bed of the stream and on these the cut-stone masonry was laid. The frost, seepage and floods of twenty years had moved the north wall so that it had settled perhaps 16 in. at the downstream end; and the masonry, which had been laid with small joints, had been separated into merely a carefully laid pile of cut stone, some of the stone having been moved fully 4 in. downstream, leaving free access for the water between each stone for a width of at least 2 in. directly against the earth of this section of the dam. It is apparent that water for a long time has gone through this wall into the interior of the earth section and eroded a considerable portion of the dam, so that its final failure was merely the collapse of the earth shell and the entire washing away of the 25-ft. section. The brick core wall remained in place unsupported, hanging from the masonry wall and the bank of the stream. It did not touch the bottom, however, at any point, although the flow of water carried away the bottom brick to a height of about 18 in. No indications of the brick having been extended below the stream level could be seen.

Repairs

The entire capacity of the reservoir was said to be substantially 1,000,000 gal. and served more for supplying the fluctuations of a day or week than for the season. The consumption of the city varies from 1,500,000 to 2,000,000 gal. per day, and as the section which went out lowered the water below the inlet into the brick gate house in the dam, it was necessary to raise the water to a sufficient elevation to divert it again into the gate house. To accomplish this a 12 x 12-in. timber was laid from the north bank to the upstream end of the wall already described and 2-in. planking was driven against the upstream edge of the timber to the bottom of the stream. The rising water on this "cofferdam" undermined this construction and water again passed through the opening in the dam. This construction has been renewed and loam thrown against the plank on the upstream side, so that the water is again diverted to the pumping station. The failure of the pressure in the city was due to inability to get sufficient water into the small basin used for a pump well to supply the pump, and this has been gradually overcome by carying the pump at a very much reduced capacity and supplying the deficiency from an emergency connection made with the Springfield system in North Main Street. The full supply could not be furnished from Springfield on account of the small pipes of the Chicopee system which are laid to the city line, 6300 ft. of 6-in. pipe forming the junction of the 12-in. main of the Springfield system and the 12-in. main of the Chicopee system in the center of the city.

Pollution of Niagara River

On Aug. 1, 1912, the International Joint Commission was requested by the United States and Canadian Governments to determine to what extent, by what causes and in what localities the boundary waters between the two countries have been polluted so as to be injurious to public health, and to propose remedies. Numerous hearings and conferences with sanitary experts have shown that at least five waterways should be investigated, but the Niagara River is the only one that has thus far been studied in detail. A preliminary report of the entire investigation has been made under date of September, 1913, by a committee consisting of Messrs. Frank S. Streeter and Henry A. Powell and issued by the commission. The following notes as to the Niagara situation are taken from the report.

New York Side

Within the State of New York the area draining into Lake Erie and the Niagara River above the falls is estimated at 2050 sq. miles but the part from which all sewage and surface drainage is discharged directly into the river is somewhat less. The population on this area is estimated at about 615,000, of which somewhat more than 500,000 are in the cities of Lackawanna, Buffalo, Tonawanda, North Tonawanda and Niagara Falls. All the sewage of the above cities, except Lackawanna, are discharged in raw state directly into the river, and the sewage of Lackawanna, also untreated, is discharged through Smokes Creek, whose outlet is 1½ miles above the head of the river. All the above cities, with Lockport (which had a population of 17,790 in 1910) and a part, if not all, of the villages near the river bank, take their public water supplies for drinking and domestic uses directly from the river.

Below the falls the waters of the river are uniformly and dangerously polluted from bank to bank and the municipalities on both sides of the river are thereby affected. Above the falls the waters at varying distances from the American bank are polluted by the raw sewage of the above-named cities, and the public water supplies of each of them, when taken from the river without purification, are in varying degrees and at varying times injuriously, if not dangerously, affected by the sewage pollution from the cities further up the river.

The location at Buffalo at the head of the Niagara River, its population (now estimated at more than 460,000) and the fact that all its sewage is untreated and is discharged into the river above the intakes of the public water supplies of all the cities below make Buffalo the most important factor in the problem of the pollution of Niagara River. Of the population within the drainage area of the river in New York, Buffalo has nearly or quite four-fifths. A large increase in the population of this territory in the near future may reasonably be anticipated and, with such increase, the necessity of diminishing the pollution of the river is apparent. What changes can be made is being officially and seriously considered. An expert report, under date of June, 1913, on the availability of Squaw Island as a site for sewage-disposal works for the city has been made. Mr. Rudolph Hering has recently been consulted by the city with reference to its sewage conditions, and his report is expected at an early date. Examination is being made of the recent progress of other cities in methods of sewage disposal.

The committee's examination of the Niagara situation is not completed and no certain conclusions can be reached. One important fact seems to have been conclusively established, however, namely, that the further discharge of raw sewage at Buffalo and other cities into the Niagara River is unwise and that it should be treated to some extent at least before its discharge into the river. The extent of such treatment is still an open question.

Related to this question is another which, from the standpoint of public health, is still more important, namely: What purification of water supplies to safeguard public health should be adopted by the cities taking such supplies from the river below Buffalo? Whatever conclusions may be reached as to the necessary requirements of sewage treatment before discharge into the river, the commissioner's present view is that all cities and municipalities taking their public water supplies from the Niagara River for drinking and domestic purposes should be required to safeguard such supplies by proper methods of purification. This seems to be demanded in any event because of occasional inevitable contamination of the river waters from surface drainage and washings from the drainage area above described which cannot be collected in any sewer system, but must flow directly into the river.

The committee therefore believes that, to secure a safe water supply from the river for cities on the Niagara frontier, two things are essential—(1) a proper disposal or treatment of the sewage and (2) filtration or other purification treatment of the public water supplies taken from the river.

It is obvious, however, that if the maximum requirement of complete sterilization of sewage of Buffalo and other cities is attempted two serious practical difficulties must be faced: (1) The great and overburdensome expense of installing and maintaining the necessary plant, and (2) the fact that complete sterilization of the sewage would not make the river a safe source of public water supply without purification.

It is hence believed that the inquiry of the commission should now be directed, first, to the extent to which sewage permitted to go into the river should be treated, and second, to the extent of purification required for water supplies taken from the river.

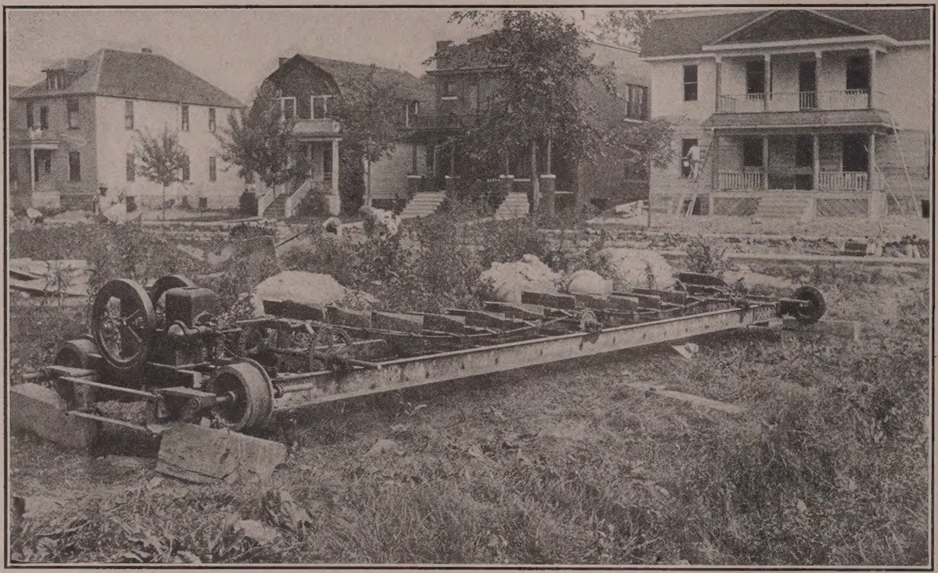
Grouping the Cities

In working out a comprehensive plan by the commission for remedying the pollution of Niagara River another matter, it is pointed out, should be considered. On the American side above the falls are the four cities, Buffalo, Tonawanda, North Tonawanda and Niagara Falls (N. Y.), named in the order of their location on the river. For practical purposes, the city of Lackawanna may also be included in this group, its sewage discharging near the head of the river. It may be assumed that each of these cities is under legal obligation not to pollute the water supplies of its neighbors on the river below. While Buffalo, from the amount of its sewage discharge, is the greatest offender, Lackawanna, the Tonawandas and Niagara Falls each in lesser degree is also delinquent.

Each of these cities will have its individual problem, but any plan to safeguard the public health by requiring artificial purification of sewage discharge into the river or water supplies taken from the river, or both, must be made applicable not to some but to all these cities. Because of diverse conditions it may not be reasonable to make the same requirements of each city, either with reference to the extent of the treatment of its sewage or the purification of its water supply. Each city contributes to the common danger, however, and each city should be required to contribute its share to the removal of that danger. To secure an equitable adjustment between the cities of those preventive measures which they must necessarily and concurrently furnish to remedy the common danger, the cases of all the cities contributing to the pollution should be heard and considered together as parts of a single case.

Canadian Side

As to the municipalities on the Canadian shore—namely, Fort Erie, Bridgeburg, Chippewa, Niagara Falls (Ontario), and Queenstown—the water supplies of all these places are taken from and their sewage (untreated) is discharged into the Niagara River, but no examination on the other side has been made except with reference to Niagara-on-the-Lake, at the mouth of the river, where the injurious effects of the pollution from the upper cities on the river have been seriously felt.



Automatic Troweling Machine with Gas Engine Drive

The Erie & Ontario Sanitary Canal Company proposes for the consideration of the commission a specific remedy for the pollution of the Niagara River by the construction of a canal starting at the mouth of Smokes Creek in the city of Lackawanna and passing around the city of Buffalo northward through a tunnel 6 miles long to Lockport, and thence over the escarpment into Eighteen-Mile Creek, emptying into Lake Ontario. A full statement of the company's purposes, what it asks for and why are set forth in its application to the Secretary of War, April 23, 1912, for the diversion of 6000 sec.-ft. of water from Lake Erie and Niagara River, for sanitation, navigation, and power. Notwithstanding the provisions of the treaty and the United States statutes relating to the diversion of navigable waters, the canal company desired to submit evidence and statements upon which it might urge the commission to recommend the adoption of its plan, and several hearings for this purpose have been held. The committee believes that these hearings should go forward to determine the feasibility of the company's scheme.

Water Power Aggregating 12,000,000 Hp is available in the national forests of the United States for development and use under permit from the Secretary of Agriculture, according to estimates given out by the Forest Service.

Concrete-Paving "Kinks"

A two-course reinforced-concrete pavement on Pasadena Street near Woodward Avenue in Highland Park, a suburb of Detroit, is laid on a soft-clay subgrade, which is drained on each side by a line of 4-in. tile laid in cinder-filled trenches, 18 in. from the curbs. The tiles are sloped to catchbasins. The pavement is 8 in. thick in the center and 6 in. at the sides, being laid on a flat rolled sub-base. The bottom layer, which is 2 in. thicker in the center than at sides to form the slopes, is of 1:3:5 mix, with the large aggregate composed of broken trap rock. The wearing surface is composed of 1 part Universal Portland cement, 1 part washed sand and 1½ parts of Wisconsin granite chips. The material is piled in the street behind a ⅓-yd. Austin cube mixer, through which mixtures for both layers are passed from each station.

Between the two layers No. 28 American Steel & Wire Company triangular mesh is secured in place by ⅜-in. steel pins 8 in. long, driven about 2 ft. apart. Baker expansion joints, at intervals of 25 ft., are held in place, while depositing the concrete, by an installation bar to insure a level road.

To reduce the hollows caused by workmen using short trowels or floats, an improved mason's darby, 4 ft. long and 4 in. wide, is used to give the final surface.

Some trouble has arisen in keeping the reinforcing from curling, and the contractor states he is of the opinion that eventually a stretcher, similar to a carpet layer, will have to be used. He would attach this at the sides to the curbs.

Another innovation, just in the experimental stage, is a mechanical troweling machine shown in one of the illustrations. It was designed to eliminate hand labor and insure a road true to grade. It consists of a frame of two 6-in. channels bent to the required crown of the street and mounted on four wheels which ride the curbs. A chain carries a series of thin steel plates, which have at the forward end a small flat portion, but parallel with the pavement, to smooth the surface and to prevent digging in with the edges of the vertical plates.

When the machine was first tried out it was pushed along the curbs and the chain turned by hand. The photograph shows it being equipped with a Gray Motor Company gasoline engine preparatory to a trial under power. Mr. R. D. Baker, of the R. D. Baker Company, contractor for the 2500-ft. stretch on Pasadena Street and a length of 1 mile on adjacent streets, is making the experiments on the troweling machine.

Using Long Float and Pinning Down Reinforcement

Miraflores Spillway Dam

It is believed that the completion of the Miraflores spillway dam constitutes a record for speed in difficult construction work on the Panama Canal, according to the "Canal Record." The waters of the Rio Grande River pass through the site, and had to be diverted three times during the progress of the work. The tracks from the Culebra cut also hampered the work. The main dam is 432 ft. long, with a bottom width of from 91 to 105 ft. There are two wing walls, each about 250 ft. long, and a core wall 134 ft. long joins the main dam with the lock walls. There are eight Stoney gates 47 ft. long and 19 ft. deep. The elevation of the crest of the dam is 38.67 ft., the bottom of the dam being at elevation 25 ft. below sea level. The elevation of the top of the gate piers is 85.17, making a total height of concrete of 110.17 ft. About 135,000 cu. yd. of excavation were required, and the concrete amounted to 73,482 cu. yd.

Factors Entering Into Grade Reductions

Analysis of the Estimated Saving in a Proposed Change from a 0.6 to a 0.3 Per Cent Ruling Grade on a Typical 130-Mile Division

Of the many grade reductions made in the last few years or under construction or consideration at the present time it is likely that in numerous instances no thorough analysis was ever made to determine the financial justification for the work, the general proposition of increased tonnages per train being considered ample to warrant it. Such an analysis is made of a 130-mile division in a paper by Mr. C. P. Howard, consulting engineer, formerly with the Illinois Central Railroad, in the August "Bulletin" of the American Railway Engineering Association. On this division it was proposed to reduce the northbound grades from 0.6 per cent maximum to 0.3 per cent, the southbound grades being let alone on account of the comparatively light traffic in that direction. These notes are taken from the paper.

The tonnages, average loading of cars and locomotive characteristics were known, and maps, profiles and general information as to operating conditions were available. The tonnage per train figured for the existing profile was 2700, while on the proposed profile it was expected that 4000-ton trains would be run. Utilizing available drawbar-pull tables and train-resistance tables for various speeds, together with acceleration and retardation curves for various conditions, two speed curves were worked out for the entire division—one for a 2700-ton train on the existing profile and the other for a 4000-ton train on the proposed profile.

From these curves it was figured that the time for the run of the 2700-ton train over the division, including five three-quarter-hour stops, would be twelve hours and thirteen minutes, while that for the heavier train on the new profile would be fourteen hours and seven minutes, the fuel consumption being respectively 15 and 19.1 tons. Thus the total time would be increased 15½ per cent and the fuel consumption 27.8 per cent.

Effect on Train Movements

Passenger trains would not be appreciably affected by the changes proposed, and it is assumed that fast-freight and local-freight trains would not be. The timetable gives a rating of 1900 tons for fast-freight trains with the given engine. As this engine could pull about 2500 tons of 38-ton cars over the steepest grade, it is not apparent that the present grades limit these trains. Similarly, southbound grades are light enough to accommodate the increased length of trains.

The present annual tonnage is 2600 trains—average weight, 2165 tons; total weight, 5,630,000. With the proposed proportionate increase in loading from 2700 tons to 4000 the average weight per train would be 3207 tons, and the number of trains, northbound, 1755. The number of trains southbound is now 2490, but there should be 1755 only for the reduced grades, as there will be less surplus power to admit of variation in length of trains. There would then be 1755 × 2 = 3510 trains, as against 2600 + 2490 = 5090 per year, a saving of 1580 trains per year. This multiplied by 129, the average length between terminal yards, equals 203,800 train-miles per annum. These figures take into consideration the reduced tonnage of the average train as compared with the calculated maximum, and show a greater saving than would be obtained by taking the figures for the maximum train. The figures for fuel consumption have been based on the maximum train, however, and it seems not improbable that the operating efficiency would be less for the heavier train, requiring a longer time to get over the division. Consequently, only the figures for the calculated performance of maximum trains are used to compute the savings in operation. These show a saving of 1355 trains, or 174,800 train-miles per annum.

Maintenance

By the report of the committee on economics of railway location of the American Railway Engineering Association, presented March 18, 1912 (referred back to the committee), the expenses for maintenance of way and structures were based on equivalent ton-miles, in estimating which the weight of freight engines was multiplied by two. As the train tonnage would be the same with the revised profile, the additional equivalent tons per mile of road would be 2 × 1355 × 227 (weight of engine and tender) = 615,000 tons.

In a former report on another division of the same road the expense of maintenance of way and structures was estimated at $620 per mile plus $105 per mile per 1,000,000 equivalent ton-miles, this being understood to apply only to the main line between division terminals. On this basis the saving would be 0.615 × $105 = $64.60 per mile, and 129 × $64.60 = $8,330 per year for the division.

As to maintenance of equipment, only freight engines need be considered. From the annual report it is found that repairs to road freight engines cost $2,421,527, and that depreciation was figured at $222,183—a total of $2,643,710; also, that there were 18,127,028 revenue freight train-miles made and 568,353 helping and light freight engine-miles made—a total of 18,695,381. Dividing the former total by the latter a repair-and-depreciation item of 14.1 cents per freight engine-mile is obtained. In a similar manner an item of 1 cent per engine-mile on account of shops, machinery and tools can be found, making a round total of 15 cents.

The freight train-miles will be reduced from 4170 to 2815, a reduction of 32½ per cent. The engine hours, however, will be reduced only 22 per cent. Assuming the engine expenses as being in proportion to the engine hours, the unit cost becomes 10 cents per engine-mile. Hence there is a saving in maintenance of equipment of 174,800 engine-miles at 10 cents = $17,500 per annum.

Transportation Expenses

Transportation expenses are next to be considered. From the annual report it is found that charges for engine-house men in freight service were $500,883. Assuming that these vary with the number of freight engine-miles, and dividing by that number, a cost of 2.68 cents per engine-mile is found, making a saving of 174,800 × 0.0268 = $4,680 per annum. It was figured that the total coal consumed would be 11.07 lb. per ton of train for present operation, and 9.55 for the 4000-ton train on the easier grades. The saving is 11.07 − 9.55 = 1.52 lb. per ton of train, or 13.7 per cent.

Assuming the superintendent's figure of 9 tons for present southbound trains to be close enough, the average both ways would be 12 tons, and the total saving would be 12 × 0.137 × 4170 (the latter being the total number of trains) = 6850 tons. These 6850 tons at $1.50 = $10,300 per year.

Items of the annual report which are taken as varying with the fuel consumption are: Engine-house supplies—freight, $52,541; water for freight locomotives, $158,712; lubricants for freight locomotives, $60,644, and other supplies for freight locomotives, $49,031—a total of $320,928. Dividing this by the number of freight engine-miles as before gives 1.7 cents per freight train-mile; and, as the fuel is reduced 13.7 per cent, the total saving is 4170 × 129 × 0.017 × 0.137 = $1,250 per annum.

Engine and trainmen's wages are estimated per hour, the amounts for ten hours being: One conductor, $4.18; two brakemen, $5.56; one engineman, $5.15, and one fireman, $3.75—a total of $18.64, or $1.86 per hour. The total number of estimated hours is as follows: For the present grade with 2700-ton trains, 4170 × 12.21 = 50,900 hours; for the reduced grade, with 4000-ton trains, 2815 × 14.11 = 39,700 hours. The time saved is 11,200 hours, and 11,200 hours at $1.86 are equivalent to $20,800 per annum.

Equipment Released

Another item to be considered is equipment released. The capitalization cost of an engine in service is considered as follows: (1) First cost of locomotive; (2) capitalized value of the annual expenditure for repairs, and (3) amount of sinking fund, which at compound interest would be sufficient to pay for renewals indefinitely. The second and third items have already been estimated. It is figured that each engine will make an average of about one trip of 129 miles per day, with an average of three engines (out of twenty-four) in the shop per day—or, say, 125 miles per day, with 10 per cent of its time in the shop, representing an average performance of 113 miles per day, or 41,250 miles per year.

It was estimated above that there would be an annual saving for the 4000-ton train of 174,800 train-miles. Reducing this proportionately to allow for the increased time of the heavier train, an equivalent saving in train-miles is found of 174,800 × 22/32.5 = 117,800 train-miles, which divided by 41,250 = 2.85 engines released. These 2.85 engines at $20,000 would cost $57,000, and the annual saving, 5 per cent of $57,000, would be $2,800.

Total Saving

Summing these items up, the total estimated saving would be as follows:

Maintenance of way and structures	$8,300
Maintenance of equipment	17,500
Transportation expenses: Engine-house men, $4,700; fuel, $10,300; water and supplies, $1,200, and train wages, $20,800	37,000
Total annual saving in operating expenses	$62,800
Equipment released, interest on cost	2,800
Total estimated saving per year	$65,600

This saving capitalized at 5 per cent amounts to $1,312,000, which is equivalent to 37.5 cents per train-mile eliminated.

Estimates were made of the cost of reducing grades to 0.3 per cent on sixteen different parts or "sections" of the district. It was recommended that for purposes of grade reduction work be done only on sections 1, 9, 13, 15 and a part of section 3. The estimated cost of reducing grades to a 0.3 per cent on these sections was much less than the estimated savings. Improvements on other sections, where the speed curves clearly indicated that the grades would ordinarily give no trouble, were not recommended. If conditions arise which make it necessary for trains to stop on these short grades often enough to cause any appreciable expense, revisions at such points may be made.

Most Economical Gradient

The 4000-ton train can be handled on a 0.4 per cent grade at a maintained speed of about 4⅔ miles per hour without the use of momentum. A 0.375 per cent grade would allow a maintained speed for the same train of 5.4 miles per hour and a 0.35 per cent a speed of 5.9 miles per hour, and it was suggested that for some of the sections the cost of reducing to these grades be estimated.

Taking the monthly average, there is little variation in the weight of northbound trains over different parts of the division. The difference is probably much greater from day to day. For instance, the engine may haul 3000 tons over one-half the division, and 2000 over the other, dropping or adding cars from time to time. Similarly after grades are reduced, it may at times be convenient to haul 3500 over one part of the division and 4500 over the other, the average weight of train per mile remaining the same, or about 4000 tons. Were the grades such as to limit the train to 4000 tons all over the division, this would then represent the maximum train, and any variation of irregularity in the length of train would tend to reduce the average below 4000 tons. This feature of operation, regardless of other considerations, might make it desirable to reduce to 0.3 per cent. The investigation was not carried far enough to estimate the saving that might result from such a reduction and its consequent greater latitude in operation. The figures indicate, however, a substantial saving for a reduction to a grade which would permit the comfortable handling of a 4000-ton train—say 0.375 or 0.35 per cent. A further study along these lines to determine the advantages of a reduction to 0.3 per cent or below might be amply justified, aside from its general interest in throwing light on conditions of operation which affect the problem of maximum economy in grades.

Concrete Trestles

Wooden bents used in ore trestles have been replaced at the Columbus works of the Carnegie Steel Company by concrete bents which were cast in forms and erected by means of a derrick car. They are 12½ ft. high, 15 ft. 3 in. wide at the base, 9 ft. wide at the top and 12 in. thick, being reinforced with ¾-in. square bars placed in pairs. The top is capped with a 12-in. channel, which acts as a support for the wood stringers, on which rest ⅝-in. stringer plates. The work was done under the supervision of Mr. W. J. Root, superintendent of the Columbus steel works and furnaces. On the new Y of the Rock Island Railroad at Joliet, Ill., there is also a concrete trestle in which both the bents and the slabs are of reinforced concrete. It is built on a long radius curve, necessitating the placing of the bents so that they conform to the curve; the side girders, however, were cast straight. Foundations were cast and the concrete was carried about 2 ft. above the ground, where forms were erected for three columns. These columns are connected at the top with a cap, which is arched in shape for appearance sake. The slabs, which were cast in an adjacent yard, were erected by a locomotive crane. The work was done by the Newkirk & Powers Construction Company, of Joliet. In both instances Universal Portland cement was used for the concrete work.

Choosing Highway Superintendents under New Illinois Law

By W. R. Robinson, Secretary and Chief Examiner, Illinois State Civil Service Commission

The Illinois State Legislature passed during its last session a bill abolishing the State Highway Commission as then constituted and creating in its place a new department with a somewhat different organization. The most marked change was the creation of the position of county superintendent of highways in each of the one hundred and two counties of the State. The term of office was fixed at six years, the salary to be set by the county authorities.

Under the supervision of the highway commission the county superintendent shall prepare plans, specifications and estimates for road and bridge work, inspect all highways and bridges in his county and supervise all construction and repair work. He shall also act for his county in all matters relating to roads and bridges, the expense for which falls either wholly or partly on the county. This arrangement will provide a representative for the State Highway Department in every county of the State and should go far toward overcoming troubles which have arisen in the past from the lack of a force of engineers large enough to handle properly all the work that the various communities wish done.

The selection of the county superintendents of highways is to be accomplished by unusual means. The statute provides that before Oct. 1, 1913, each county board shall nominate to the State Highway Commission not more than five nor less than three residents of the county as candidates for the position. The commission is then required to determine, by competitive examination, the relative fitness of the applicants for each county and to certify to each county board the names of its candidates who are properly qualified. From this list one person is to be selected and appointed to the position of superintendent. If none qualify, a second list of candidates is to be submitted, and if none qualify this time, some person may be selected who is not a resident of the county but who has qualified in some other portion of the State.

The examinations are to be held on Oct. 18, 1913, in seven cities so located as to be easily accessible to all candidates. The use of reference books, statutes, reports of the commission, slide rules, formulæ and tables will be permitted.

It was evident to the highway commission that conditions varied so in the many counties of the State that the qualifications necessary in one county might not suit at all in another and that consequently the examination given must also vary according to the needs of the situation. The counties were, therefore, divided on a population basis into three groups. The first group contains sixty counties, with a population under 30,000; the second group of forty-one counties, having between 30,000 and 200,000; the third group of one county of more than 200,000 population.

Scope of Examination

In the first group of counties the examination questions will be divided into three general sets, covering (a) training and experience of the applicant along lines tending to fit him for the position sought; (b) technical or theoretical knowledge; (c) practical questions. The same three sets will be used in the second and third groups of counties, with the addition of a few questions on drawing up and interpreting specifications applying to road and bridge work.

The standards set for the subjects of training experience will vary in the different groups. In the first group five years' practical experience on road work will be expected, and preference will be given to men who can run levels and do simple surveying. While no educational requirements are fixed, the candidate's schooling will be considered in fixing his standing. Candidates in the second group are expected to be familiar with concrete construction. Time spent at a recognized school of civil engineering will be counted one-half toward the required five years. For the third group, in addition to technical training in a recognized school, the candidate's experience must cover five years of design and supervision of construction of roads and pavements, and of steel and concrete bridges and culvert construction. It will be seen that the commission desires engineers for the second and third groups but does not expect to secure them for the first.

The technical questions will vary from ordinary arithmetical calculations for the first group to the use of trigonometrical formulæ and principles of mechanics in the second, and to the design of roads and pavements, concrete and structural steelwork in the third.

The practical questions will bring out the candidate's experience in handling men and supervising construction work of various kinds. Various features of road and bridge work will be touched upon.

The weights given the various parts of the examination are different in each of the three grades, more stress being laid on the training and experience of the applicant and on his answers to the practical questions in the first and second groups and a higher weight being assigned to the technical knowledge and questions on specifications for the third group.

It will be noticed that this examination will make no attempt to inquire into the personal characteristics of the candidates or their standing in their community. It is presumed that the county commissioners have taken these phases of the matter into consideration in making up their lists of candidates to be submitted to the State commission.

Kaiser Wilhelm Canal Improvements

The widening and improving of the 61⅓-mile Kaiser Wilhelm Canal, connecting the North and Baltic Seas between Brünsbüttel and Kiel, Germany, will soon be completed, according to a recent consular report. The building of this canal was begun in 1777, and as the Eider Canal it was completed in 1785, with locks 26.24 ft. wide and 104.9 ft. long and a navigable channel 11.48 ft. deep. Reconstruction began in 1888, and upon termination of the work in 1895 the canal was given its present name. The depth was then from 30 to 32 ft., and the locks were 708 ft. long and 85 ft. wide, although the usable dimensions were only 492 and 69 ft. respectively. The new locks which are about to be completed are somewhat larger than those of the Panama Canal. They are 1082 ft. long, 147 ft. wide and 44 ft. deep. The canal channel is 46 ft. deep. The lock gates are of the sliding-door type, moving at right angles to the lock chamber to open or close the lock. Each gate is 59 ft. high and 154 ft. long. It is made up of two walls of steel 26 ft. apart, with an air space between, divided into chambers which can be filled or emptied at will to facilitate and safeguard the operation of the gate. The weight of each gate is 1250 tons.

AMERICAN ROAD CONGRESS

Abstracts of Some of the Papers Presented at the Third Annual Convention in Detroit, September 29 to October 4

Selection of Materials for Macadam Roads

By Logan Waller Page, Director, Office of Public Roads, Washington, D. C.

The first and only certain way of selecting proper roadmaking materials is to make an actual service test. This method is, of course, impracticable except in certain rare instances, due to the length of time which must elapse before definite results can be obtained. The second method is to approximate, by means of short-time laboratory tests, the destructive agencies to which the material will be subjected on the road, supplementing the knowledge thus gained by a study of the results already obtained in practice on material of a similar nature.

The laboratory testing of roadbuilding materials originated in France more than forty years ago, and was introduced into this country by the writer in 1893, when he became director of the road-material laboratory of the Lawrence Scientific School at Harvard University. The three most important properties which a rock should possess in order that it may successfully resist the destructive agencies to which it is subjected are hardness, toughness, and cementing value.

Hardness and Toughness

In determining hardness a core 25 mm in diameter is drilled from a sample of the solid rock. After being accurately weighed it is held in a perpendicular position against a cast-steel disk revolving at the rate of 33 r.p.m., while crushed quartz sand of a standard size is fed upon the disk to act as the abrasive agent. After 1000 revolutions of the disk the core is again weighed, the loss calculated, and a measure of the hardness of the rock thus obtained.

To determine toughness a cylindrical specimen of the rock 25 x 25 mm is taken from the core used in the hardness test and subjected to the impact of a 2-kg hammer through a spherical end plunger. The test consists of a 1-cm drop of the hammer for the first blow, followed by an increase in the drop of 1 cm until failure occurs. The height of blow at failure represents the toughness of the specimen.

The combined effect of the mechanical wearing agencies is determined by means of the Deval abrasion test, the standard for more than thirty years. Five kilograms of the rock are broken so as to number fifty pieces, which are placed in an iron cylinder whose axis is inclined at an angle of 30 deg. with the axis of rotation of the machine. After 10,000 revolutions of the machine at the rate of 33 per minute the material is taken out and sieved through a 0.16-cm sieve, the material passing being that used in calculating the percentage of wear.

Cementing value is determined by a test devised several years ago by the writer. Five hundred grams of the material are broken to about pea size and placed, together with a sufficient quantity of water, in an iron-ball mill. Five thousand revolutions of the mill reduce the mixture to the consistency of a stiff dough, which is molded by means of a hydraulic molding machine into cylindrical briquettes 25 x 25 mm in size. After drying twenty-four hours these briquettes are tested by impact. A 1-kg hammer is allowed to drop from a height of 1 cm upon an intervening plunger, which in turn rests upon the test piece. The number of blows causing failure represents the cementing value of the material.

The results of laboratory tests, though valuable, are not sufficient to judge of the suitability of a rock for roadbuilding purposes, unless supplemented by additional information as to the character and volume of the traffic to which it is to be subjected, climatic conditions under which it is to be used, and its name and general character, including, if possible, its mineral composition. In addition to the above, consideration in any specific instance should be given to such matters as the availability of the material, especially with reference to cost, transportation facilities, etc.

Ideal Rock

The ideal rock for any particular road should be just so hard and tough that the fine material worn off by the action of traffic would be sufficient to supply that lost by the physical agencies of wind and rain. By correlating the information gained from observation of various kinds of rocks with the results of laboratory tests under similar conditions it has been found possible to determine quite definitely, even before a material has been used in road construction, under what conditions it would be most suitable. Many years of observation of the behavior of the various roadbuilding rocks in service have established the general rule that certain classes of material possess particular advantages over others for definite purposes. It is obviously advantageous, therefore, to know the general type of the material under observation in order that intelligent comparison with similar rock already in use may be made. The different varieties of trap, such as diabase and basalt, are generally considered as making the most satisfactory road material, especially when the traffic is heavy enough to supply by wear the dust lost from natural causes. The limestones, as a class, being softer and less tough, are as a rule better adapted for light traffic than the traps. Laboratory tests in these cases are, therefore, mostly of value in enabling the engineer to make a definite choice between a number of materials which in a general way might be considered as suitable for his work.

The granites, owing to lack of toughness and cementing value, are, as a rule, only suitable for the foundation courses in plain macadam construction. Frequently granites are found by laboratory tests to have good cementing values, due to highly altered minerals, when, as a matter of fact, such material should not be used on account of the ease with which it disintegrates under traffic.

Foliated material, such as gneiss, schist, slate, etc., should never, of course, be used when better material is available. Material such as quartzite and marble should also be avoided, the first on account of its hardness and lack of cementing value and the second because of its crystalline structure and general lack of durability.

Availability of Materials

The availability of various materials considered for use in road construction should, of course, be considered, and is highly important, especially from a financial standpoint. In considering this point, however, care should be taken not to lose sight of the other factors in the case. Experience has shown in innumerable instances where poor material has been used because it was cheap that money would have been saved in the long run by the use of a superior rock, even though shipped from a distance and costing considerably more at the outset. There are cases, however, where local material may be used advantageously. It is in such instances as these that engineering judgment, combined with laboratory results, is necessary for proper selection.

Numerous tests seem to show that hardness is invariably accompanied by toughness, although the reverse is not the case. For a quick determination, therefore, the hardness test might possibly be omitted, since material which satisfactorily passes the toughness requirements invariably appears to be hard enough for use in road construction.

Bituminous Construction

When rock is to be used in bituminous construction the cementing value may be practically disregarded. Toughness and per cent of wear also become less important, as occasional surface treatments preserve a wearing mat with a hard and tough aggregate.

For cold surface treatment the oils which give particular satisfaction are the natural or partially refined products which, through laboratory tests, are shown to consist of low-boiling constituents carrying in solution a relatively high amount of heavy adhesive asphaltic base. For most successful surface treatment it is essential that an oil shall develop decided adhesive qualities in the residue from the standard volatilization test at 163 deg. C. Tar products should be free from water, and it is believed that their value for surface treatment increases with the decrease in the free carbon content.

In rural districts with slight automobile traffic light, dust-laying oils suffice. For a traffic making greater demands a heavy binder as an integral part of the upper two or three inches of the wearing surface must be used. The selection of a binder is dependent on several factors, among which the method of construction, character of the aggregate, and climatic conditions are most important. For instance, a dense aggregate may permit of the use of a lighter tar than a poorly graded one; or a lighter tar or softer asphalt product would be specified for northern latitudes rather than for use in the south. A single standard for all materials and conditions cannot be established; but with the various factors in mind a specification can be drawn to cover the consistency and desirable chemical characteristics. In fact, in the purchase of road materials for whatever purpose it should be to the advantage of the producer as well as a protection to the consumer that a definite specification be required. All shipments when received should be submitted to laboratory tests that will insure fulfilment of these specifications.

Unsurfaced Roads

By W. S. Keller, State Highway Engineer of Alabama

Unsurfaced roads are divided into three classes. The first includes those opened when this country was young. We have roads in Alabama that were opened by Gen. Andrew Jackson, both on his march to fight the British at New Orleans and in quelling the Indians in South Alabama and Florida. Although it is difficult to better the alignment of these roads on account of homes, churches and schools which have been built close to them, many are being changed to meet the demands of traffic. The genuine bad roads of the South belong solely to this class. They cannot be maintained for the reason that they have never been constructed and until they are relocated, avoiding heavy grades and marshy bottoms, sharp angles and useless twists, and are graded to secure good drainage, we may expect them to be bad.

Unsurfaced roads of the second class are the ordinary graded earth roads which have proper alignment, grade and drainage. Their construction demands, first, a careful inspection by the proper official to determine what beneficial changes in grade and alignment can be made, taking into consideration initial cost and cost of maintenance. The center line and grade of the road should be established by an engineer. The proper and efficient grading force for the work consists of a foreman, eight or ten good two-horse teams with drivers, one wheel and one drag scraper for each team and one extra wheeler and drag for emergencies, one railroad grading plow, one grading machine, one split-log drag, one dump man and one loader, with five or six extra men for grubbing and other work. The foreman should be an experienced grading man.

We have in the South nearly every kind of soil from sticky gumbo to course sand. The worst roads by far are in our rich and fertile prairie lands, where the soil readily absorbs water, becoming very sticky after rains. It expands freely and dries rapidly when the sun shines and becomes very hard under the tamping effect of teams and vehicles. From observation and experience I have learned that these roads, of all others, require a very high crown and the driving surface should only be wide enough to allow two vehicles to pass. If a road is narrow, with a fall of not less than 1½ in. to the foot, water will shed rapidly to the ditches and the entire surface will dry out rapidly. A road of this kind can be constructed quickly and at little expense, except where grades are to be reduced or bottoms filled with a grading machine or even with a split-log drag. The latter method will require more time, but in the end it will be found to be very satisfactory. No earth road can be maintained in good condition unless it is so constructed as to drain well.

The third class of unsurfaced road includes those in sections of country where the soil or earth is really roadbuilding material, composed either of gravel, sand clay or top soil, so that when the road is graded it is, in fact, surfaced. Where this condition exists splendid roads can be built at a minimum cost.

The maintenance of unsurfaced roads is radically different from the maintenance of surfaced roads. For instance, the patrol system used on macadam roads would be entirely inadequate for earth roads. One man can keep up 2 or 3 miles of macadam road where he would unquestionably be unable to keep in good condition a like amount of unsurfaced road. With the use, however, of a team and drag he would be able to keep in good condition 20 miles of ordinary graded earth road. It has been difficult to convince county authorities in the South that this little machine is of value.

As an inducement to the men to do good work, one county offered prizes of $25, $15 and $10 for the best-kept roads. The most interesting fact connected with the contest was that the road which was awarded first prize cost the county only $15, or $5 per mile.

In many southern States the roads are maintained by what is known as statute labor, which means that a man may work out his road tax under the direction of a district overseer. Such labor is practically worthless and few men are required to work out the stipulated number of days.

Waterway Structures for Roads

By A. R. Hirst, State Highway Engineer of Wisconsin

Wisconsin gives State aid to bridges and culverts, as well as to roads. All waterway structures 6 ft. and under in span are classed as culverts, and are built out of the funds available for the construction of the road. All waterway structures more than 6 ft. in span are considered as bridges and must be provided for by separate appropriations, the State paying 20 per cent of their cost instead of 33⅓ per cent, as in the case of culverts on roads.

Wisconsin has a drastic bridge law which provides that culverts under 18 in. in span must be constructed or reconstructed to stand without planking a load of 18 tons, and waterway structures of greater span must be designed "in accordance with standard engineering practice," to stand a load of 15 tons without planking. In addition to the duty of designing all State-aid bridges and culverts the State highway commission is obliged to investigate as to safety and engineering sufficiency the plans of all bridges constructed with county aid.

Five Classes of Bridges

Bridge superstructures may be divided into five classes, according to span. Spans from 18 in. to 10 ft. are almost invariably constructed of reinforced concrete of the slab type. We are building even the smallest culverts of reinforced concrete, as they are entirely serviceable, easily constructed and in probably 50 per cent of the cases cost less than any other type of culvert except wood, which is not allowed on any of our work. The smallest concrete structure we are now building is 18 x 12 in.

In some cases we use culverts of corrugated metal, with concrete or stone end walls, but only where it is impracticable to use concrete. Vitrified clay is not used at all on State-aid work, as it almost invariably cracks by filling and freezing. The use of concrete pipes molded in place and afterward moved to the job is avoided for the same reasons. Both make excellent culverts under favorable conditions, and we recommend them for less severe climates. Cast-iron water pipe has not been used on account of its cost. In these small culverts the average cost per cubic yard complete, including the excavation and backfilling, is about $8 and very seldom exceeds $10 per cubic yard.

Spans from 10 to 40 ft. are either reinforced concrete—the slab type up to 18 ft. and the through-girder type up to 40 ft.—or I-beam structures with concrete floors. With public lettings open to any bidder, the workmanship and finished appearance of reinforced-concrete bridges have been so poor in many cases that we are using more I-beam structures than we otherwise would. A 5-in. concrete floor is placed on top of the I-beams, and the corrugated arch type of support between the I-beams is but seldom used.

Spans from 40 to 80 ft. usually employ the Warren riveted pony truss, though a few plate girders are being used where hauling conditions are favorable. All of these structures have concrete floors.

Spans from 80 to 135 ft. take the riveted Pratt high truss with a horizontal top chord, also with a reinforced-concrete floor.

Spans of more than 135 ft. use a Pratt riveted high truss with a curved top chord. Practically all of these larger spans are built with a reinforced-concrete floor. Probably once in twenty-five cases is a pin-connected truss used.

Our cost figures on all bridges show that for any span the price, erected, including substructure and superstructure, figures out very closely to $40 per linear foot of the over-all span. Reinforced-concrete floors average about 20 cents per square foot. Steel in plate-girder and truss spans averages from $65 to $70 a ton erected, and I-beam spans, $50 to $60 a ton erected.

We have adopted for widths of concrete culverts and bridges the standards recommended by the Association of State Highway Departments, which are as follows:

Width of Culverts and Bridges

	Min. width, ft.
First-Class Roads	
Culverts under 12-ft. span	24
Slab bridges more than 12-ft. span	20
All other concrete spans	20
(Very long bridges less if necessary)	
Second-Class Roads	
Culverts less than 12-ft. span	20
Slab bridges more than 12-ft. span	18
All other concrete bridges	18
Third-Class Roads	
Culverts less than 12-ft. span	20
Slab bridges more than 12-ft. span	18
Longer bridges may be	16

Steel bridges are built almost invariably with a 16-ft. roadway—that is, 16 ft. clear distance between trusses or rails, no matter what the class of road, although for spans under 80 ft. some 18-ft. clear roadways have been built.

Abutments under practically all structures are plain concrete. The price of concrete in bridge abutments and piers averaged last year about $8 per cubic yard.

We have found it necessary to have open competition and sealed bids on bridge work, and by asking for mailed bids on all work have established true competition and largely broken up the old system of "pooling." We furnish complete plans for foundations and for reinforced-concrete, I-beam and plate-girder spans, and all bidders submit prices on our uniform plans. For truss spans we furnish the truss diagram showing the stresses in the truss members and the arrangement of the parts, and the successful bidder submits for approval the shop drawings before fabrication is commenced. For trusses we believe the latter system is preferable to that of furnishing complete shop drawings, as it allows manufacturers to follow their standard shop practice in detailing so long as these details are satisfactory.

The design of culverts and bridges should always be left to engineers. The cost of designing, letting and accepting bridges in Wisconsin has averaged about 3½ per cent of the total cost.

California's $18,000,000 State Highway System

By Austin B. Fletcher, State Highway Engineer of California

From north to south California is more than 700 miles long; its area is 158,360 sq. miles. The highway system, for which $18,000,000 has been appropriated, will comprise two main or trunk roads, one along the coast and the other traversing the great Sacramento and San Joaquin Valleys, as well as tributary highways to the seats of outlying counties. It is probable that before the State highway system is complete the counties will have provided for an expenditure of more than double the $18,000,000 which the State will spend.

It was found that to comply with the terms of the act not less than 2760 miles of road must be taken into the system, which means that the average cost per mile of road built must not exceed $6,500, including expenses of administration. Since this sum per mile is nearly $5,000 per mile less than some of the Eastern States are paying for their highways, it follows that it will not be possible to pave the surfaces of all of the roads.

After months of study the following allotment of the fund was agreed upon tentatively:

Allotment of Fund

Trunk Lines	
1,305 miles requiring paving, at $8,620	$11,249,246
480 miles surfaced with local materials, at $5,944	2,852,905
Laterals	
785 miles at $2,881	2,261,485
Add 10 per cent for administration, surveys and engineering	1,636,364
Total bond issue	$18,000,000

Fortunately nearly every county in the State has agreed to build and pay for the bridges along the State highway routes and to furnish without cost to the State all land needed for the locations of the State roads. Without this county assistance and without the extremely low rates for the haulage of materials which the railroads have granted the task of completing the system with the sum of $18,000,000 would have been hopeless indeed.

Types of Work

For a large portion of the roads the commission has adopted a pavement consisting of a Portland cement concrete base of a minimum thickness of 4 in. and 15 ft. wide with shoulders at least 3 ft. wide on each side of the concrete. The concrete base is covered with a thin coating of asphaltic oil and stone screenings, forming a bituminous carpet from ⅜ to ½ in. in thickness to serve as a wearing surface and to protect the concrete. In the environs of San Francisco and elsewhere thicker bases and wearing surfaces are specified.

As guiding principles the commission has tried to obtain a readjustment of the road locations to secure proper alignment; rights of way of uniform width, preferably not less than 60 ft.; maximum gradients in the mountainous country of 7 per cent and minimum radii on the center lines of such roads of 50 ft., with a clear sight of at least 150 ft. wherever practicable; permanent culverts, gutters and ditches wherever needed to prevent water from standing on the roadsides and on grades to prevent gullying due to the water accumulating in volume; bridges, preferably of reinforced concrete, at least 21 ft. wide in the clear and designed to carry 16-ton traction engines; minimum width of roadway of 16 ft. to apply only to those places in the mountains where there is so much rock as to make a greater width prohibitive and an average width throughout the remainder of the State of 24 ft. on embankments, of 21 ft. in through cuts and 22½ ft. where the road is part cut and part fill; a crown varying from 1 in. to the foot where no surfacing is applied to less than ⅜ in. where bituminous surfaces are used, in all cases the crown to be the least needed to cause the water to run quickly from the road into the gutters; such type of surfacing as the needs of the locality require, varying from the graded road to the highest type of asphalt paving and from 15 ft. to 24 ft. in width; the erection of guard rails at dangerous points on grades and on high embankments; the trimming of slopes along the road sides, both old and new, so as to prevent the unsightly gashes now so noticeable along the roads and the planting and fostering of suitable trees indigenous to the locality; and the placing of permanent monuments at the time of construction along the roads to mark accurately the right-of-way, as well as the erection and maintenance of guide boards marked to show places and distances accurately.

Kinds of Paving and Cost

	Miles	Cost per mile	Cost per sq. yd.
Asphalt on concrete base	6.6	$14,920	$1.06
Asphalt on macadam base	11.5	8,403	0.716
⅜-in. surface on concrete base	198.1	6,394	0.712
Bituminous macadam	19.1	6,364	0.723
Waterbound macadam	7.6	4,303	0.489

The table above shows the different kinds of paving which the commission had under contract Aug. 1, 1913, together with the lengths and costs. The figures do not include the costs of grading, culverts, etc., nor of administration.

Thin Roads

As will be noted in the foregoing table, nearly 200 miles of the State highway are being constructed with a ⅜-in. wearing surface on a concrete base. The specifications provide that the base shall be of a minimum thickness of 4 in., but discretion is given to the highway engineer to increase the thickness of the base. A base so thin as this would not meet the approval of the writer for use in many parts of the country, but in the moderate climate of those parts of California it will doubtless be adequate for all time. Great care is employed in securing a rigid subgrade.

The concrete is laid without expansion joints. It is observed that at intervals of about 30 ft. natural contraction cracks develop. These cracks are filled with heavy bituminous material as soon as they are wide enough to receive it. It is believed that with the thin wearing surface it is much better policy to omit the artificially made joints, and that the road surface will consequently be much smoother to ride upon.

Some contractors have called the roads "painted concrete," and insisted that the asphaltic surfaces should be not less than 2 in. in thickness, consisting either of sheet asphalt or one of the "bitulithic" variants. Were it considered desirable to adopt their suggestions, there is money enough in the appropriation to complete only a small part of the system in that manner and do justice to the remainder of the State, and the commission has concluded to continue with the thin surface, renewing it as often as is necessary. The thick surfaces would cost more than ten times as much as the original cost of the thin surface, and it seems probable that the interest on the excess cost will pay the cost of renewing the thin surface.

Some of the "painted concrete" has been under traffic about eight months, with a complete satisfaction of all requirements.

Maintenance

To provide money for maintenance the Legislature of 1913 passed a new law setting up a system of graded fees for the annual registration of motor vehicles. By Jan. 1, 1914, when the act takes effect, there will be not less than 100,000 motor vehicles in operation on the highways, and the total fees received will doubtless be in excess of $1,000,000 for the year 1914. After the expenses of the registering department are deducted, one-half of the remainder goes to a fund for the maintenance of the State highways, the other half being appropriated for the maintenance of county roads. Thus for the year 1914 it is estimated that more than $450,000 will be available for the upkeep of the State highways.

Bituminous Construction

By S. D. Foster, Chief Engineer, Pennsylvania State Highway Department

The experimental stage in road-foundation work has been passed, and for the ordinary country traffic to which the average highway must be subjected an 8-in. telford foundation or a 5-in. cement-concrete foundation, when properly constructed, is sufficient for the carrying of any class of pavement.

The principal features to be considered in choosing a binder are the characteristics of the stone to be used, the manner of applying the bituminous cement (whether the material is to be applied hot or cold, by means of distributors with or without pressure, or by pouring-pots), the quantity and character of traffic to which the road will be subjected, climatic conditions, the cost of bituminous material, and the probable cost of application.

The cause of failures in penetration work can be traced in many instances to faulty plans and specifications, lack of care and judgment in the selection of materials, poor and inadequate equipment with which to carry on the work, inexperienced labor for both skilled and unskilled service, continuation of work during unseasonable or inclement weather, and insufficient funds to expedite the work under way. Probably the most noticeable cause of failure is that a class of incompetent contractors, having absolutely no experience in bituminous construction, bids on highway work and looks to the engineering department as a school of instruction for their guidance.

Where penetration pavements are supervised under the most expert management, the results at best are only those of a surface character and produce a road that for the time being seems to give satisfactory results.

Mixing Method

The mixing method eliminates many of the causes of failure found in penetration construction. While the best results from this type of pavement are obtained by using a cement-concrete foundation, it is not absolutely necessary that such a foundation be used. Experience has demonstrated that water-bound macadam roads, where they have been properly drained, can be resurfaced with a mechanical mixture, the results comparing favorably with those of sheet-asphalt streets. This type of construction has been a success and I feel safe in saying that most of the old water-bound macadam roads that have been torn by the heavy traffic can readily be brought to grade, properly crowned, made firm, and covered with a bituminous concrete that will be economical and serviceable for many years.

A telford foundation is not ideal for a mechanically mixed surface, as it is almost impossible to obtain a surface that will not be wavy.

There is a tendency in all revolving mixers to bring the large stone together, and unless in the dumping of the mixer this is closely watched the purpose of mixing will be defeated. If the material has to be transported a very great distance from the mixer to the road there will be a tendency for the larger stone to work toward the top of the load and the smaller material toward the bottom. The material should first be dumped on a platform and from there shoveled into place in as uniform a mixture as possible.

I have used two distinct types of mixed bituminous construction. One is a cut-back bituminous material which remained in a plastic state for several days after being placed on the road, bringing about a continuous bonding process by means of local traffic passing over the road. This resulted in a perfectly smooth and uniform surface, in which there was probably from 70 to 80 per cent of mineral aggregate exposed, which furnished traction for horses' shoes and automobile tires, thus eliminating one of the great criticisms of this type of pavement. The other type is a straight bituminous material of approximately 60 to 70 penetration, upon which a seal coat was used to obtain a smooth and compact surface.

I do not believe it wise to use in the construction of a pavement upon cement-concrete foundation any stone larger than will pass through a 1-in. ring, inasmuch as in this type of pavement while the load is seemingly carried upon the surface, it is in reality carried directly upon the foundation; and if stone larger than 1 in. in size is used there will be a likelihood of the larger stones crowding one on another, thus throwing open the chance of fracture to either or both stones by impact from horses' shoes or weight from the tires of heavily loaded wagons.

Merit System in Road Management

By John T. Doyle, Secretary, United States Civil Service Commission, Washington, D. C.

In the good-roads movement the merit system is essential. The public roads constitute a series of great transportation systems which should be administered with all the business care and efficiency and all the technical skill that would be employed if they were owned by private corporations. Instead of that we have the spectacle of a hundred thousand or more road officials, most of them elective and very few of them required, under existing legislation, to have any knowledge of road construction and maintenance or to give any considerable amount of their time to the management of the roads. It is estimated that more than $150,000,000 a year is being expended for the construction and upkeep of our public roads. It therefore becomes an important economic essential that this great outlay be expended under trained, capable and honest supervision.

The merit system of appointments was adopted in the Federal Government and in the State and city services of New York and Massachusetts nearly thirty years ago. The beneficial effects of its enforcement and of its continued development and increasing application are now more than ever apparent. Appointments and removals in the more than half million positions in the parts of the service under the merit system of the nation, States and cities are withdrawn from politics and made with increasing regard to the interests of the public service, and a higher order of character and efficiency is manifest in those services.

The merit system has been the means not merely of supplying qualified technical experts and of opening a worthy career of public employment to them, but of aiding the orderly development of technical work in the public service which was not possible under the debasing influences of the spoils system. Since the adoption of the merit system there is an enormous expansion of technical activities in the nation, States and cities, and a wide field of usefulness has been opened to persons of technical education, with tenure based solely upon fitness. The public service is becoming more inviting as a field of employment, and on its technical side offers opportunity for research and broadening of training.

Civil Service Appointees

Appointing officers who have had experience in employing men through civil-service examinations recognize that competitive tests are better than those heretofore employed. In Philadelphia the chief of the Bureau of Highways and Street Cleaning, an office with a salary of $6,000, and nine assistant commissioners of highways have been appointed by competitive examination. Experience in that city and in New York, Chicago, and other municipalities demonstrate that the competitive system is adapted to the highest administrative and expert places in city governments.

The position of assistant director in the Office of Public Roads has recently become vacant by resignation and the commission has been requested to hold an examination to fill it. An examination will be announced in the near future to fill this position at $3,500 a year. The duties are largely administrative and supervisory and entrance to the examination will be limited to persons having an engineering education who in addition have had extended experience in highway engineering work. The relative qualifications of the applicants will be determined from their statements of education and experience, both in highway engineering and in supervisory positions, and from a consideration of their publications, together with statements concerning their fitness for the position secured from persons acquainted with their work.

The State and city governments which do not have merit laws should be urged to follow the example of the National Government and the larger States and cities and place their services upon a merit basis. Because of the efficiency and stability in the administration of the civil service in the National Government and its freedom from political abuses the public is looking more and more to the National Government to do things which under our scheme of government properly should be done by local authorities. It is urgently necessary that the local governments should realize their duties and responsibilities in this regard. The demand is widespread that the people shall be efficiently served, that their common affairs shall be honestly and intelligently administered, and if the local authorities do not meet this demand there will be increasing centralization in the government of the nation.

Bond Issues for Road Improvement

By S. E. Bradt, Secretary, Illinois State Highway Department

The Office of Public Roads states that the United States has approximately 2,200,000 miles of country highways, that 15 to 20 per cent of main highways carry from 80 to 90 per cent of the total traffic, and that 15 to 20 per cent of highways carry about 60 per cent of all farm traffic. This mileage of 20 per cent will be sufficient to cross most of the States both north and south and east and west every 6 miles, and will include all of the main market roads, intercounty, interstate and transcontinental highways. Fifteen to twenty per cent of this 2,200,000 miles would be approximately 400,000 miles. It is estimated that 11 per cent of our roads are already improved. Probably less than 5 per cent, or 100,000 miles, are so improved that they will give a wear of more than ten years, so that the mileage yet to be improved is not less than 300,000.

Let us divide this 300,000 miles into roads connecting all State capitals and larger cities, comprising approximately 50,000 miles, and main market roads connecting the county seats, cities and villages of the different states, comprising approximately 250,000 miles. The first 50,000 miles, the main traveled roads, should be 18 to 20 ft. in width. The roads connecting the smaller centers of population could vary in width from 12 to 16 ft., depending on the probable traffic.

Roads for Heavy Traffic

The rapid increase in the number and weight of motor vehicles adds to the cost of improvement. Motor trucks, much more destructive to roads than automobiles, will at no far distant day come into general use, carrying freight from city to country and farm products. Our main traveled roads, therefore, must be built to standard grade if possible, with a substantial foundation and hard-wearing surface, such as brick or concrete. To accommodate the traffic the 50,000 miles, 18 to 20 ft. wide, would cost not less than $15,000 per mile, or a total of $750,000,000 for the entire mileage. The 250,000 miles from 12 to 16 ft. in width would cost approximately $10,000 per mile, or $2,500,000,000 making the total cost of the entire 300,000 miles $3,250,000,000.

The broadening public sense of good-roads value brought the administration from township to county and from county to State, or the State-aid system. It is now becoming apparent that we shall need the assistance of the Federal Government, as the people are awakening to the fact that road improvement is essential and urgent; that the task is so great that all the forces must combine for its solution.

If all the road associations could unite in asking Congress to authorize the appointment of a commission to conduct a thorough investigation and report a plan recommending the extent to which the Government shall enter into this work this great project would soon be under way.

It seems reasonable to ask that the Government shall over a period of fifteen or twenty years assist in this road movement, at least to the extent of building the 50,000 miles of interstate highways at a cost of $750,000,000, issuing bonds if necessary. There would still remain the sum of $2,500,000,000 to be contributed and expended by the States and counties, in proportion to the total mileage of each State. This amount of money spread over a period of fifteen years would mean an annual cost of $166,000,000 to the States and counties of the nation. This is indeed a large expenditure, but as the roads to be improved carry 80 or 90 per cent of the traffic on which there is an estimated annual loss of $250,000,000, there would result a saving of $200,000,000 or $225,000,000 annually; thus the improvement would soon pay for itself. Again, we are expending annually on our roads and bridges $180,000,000, $150,000,000 of which is being raised by general taxation and $30,000,000 by bond issues, sums greatly in excess of the annual expenditure called for in this proposed system. However, a bond issue would seem necessary.

Traffic requirements for the next twenty years may be judged sufficiently well to allow building roads to meet them. The coming generation, then, should share in the cost. Bonds are freely issued for other public improvements, such as waterworks, sewer systems, lighting plants and school buildings, many of which require frequent renewals, and all, maintenance. If the work of building this system of roads is spread over fifteen years, building one-fifteenth each year, paying half the cost of this portion by direct tax, and issuing fifteen-year bonds for the remaining half, the cost would be distributed through thirty years; but each section would be paid for within fifteen years of the time of its construction. The burden upon the taxpayers would be only little more than at the present time; further, through a proper organization of the work by States and counties the money could be conserved and real value would be received.

Towing Locomotives for Panama

Tests of the sample double-truck towing locomotive conducted at the Gatun locks of the Panama Canal demonstrated that the machine is not entirely satisfactory, according to the "Canal Record." The locomotive was built by the General Electric Company, and the arrangement was that thirty-nine others of the same type were to be built if the first one proved satisfactory. The proposal included figures for an alternative single-truck design, and forty of the latter type, with certain modifications, have been ordered. The chief defects found in the trial were the unreliable frictional action intended to prevent the drum from turning before the desired pull had been reached; the narrowness of the winding face of the slip drum, causing the layers of rope to overlie each other unevenly, to the injury of the rope; the vibration due to the uneven surface of the rack rail which engages the thrust wheels to hold the locomotive to the track under the horizontal pull of the line, and the failure of the pinion to engage, without shock, in the approach racks placed at the point where the speed of the locomotive changes from the return speed to the towing speed. In the new locomotives the solenoid-operating clutches and friction gear will be omitted, hand-operating clutches and equalized hand brakes will be added, and other changes will be made. The cost per engine will be increased by $1,543, making the total cost per locomotive $13,217. Delivery of the first is to be made in seven months and that of the others at the rate of four per month.

Railroad Operating Revenue for June on the large steam roads of the United States, as given in a bulletin issued by the Interstate Commerce Commission, amounted to $253,356,489.71, an increase of $15,992,193.36 over June, 1912; operating expenses were $178,394,785.37, an increase of $15,744,779.64; and net operating revenue was $74,961,704.34, an increase of $247,413.72. The operating ratio increased from 68.52 to 70.41 per cent.

Loss of Head in Pipe Bends

Compilation of Existing Data in Form for Use by Waterworks Engineers

The increasing number of pumping stations and filter plants requiring sharp curves in piping systems has directed attention to loss of head caused by bends and to the lack of agreement among investigators in this field of hydraulics. To assemble existing data in a form readily usable under ordinary conditions in waterworks practice is the purpose of the paper which Mr. Weston E. Fuller, consulting engineer, of New York, presented before the New England Waterworks Association on Sept. 11. The paper is reprinted below in slightly condensed form.

Loss of head due to bends will be considered as that portion of the total loss in excess of the loss which would occur in an equal length of straight pipe.

The effect of both the radius of the bend and the velocity must be determined for pipe of different sizes.

Until recent years Weisbach's formula, based upon experiments made on small pipes, was generally accepted. This formula is: h_b (additional loss of head due to 90-deg. bend) $= 0.13 + 1.85\ D/r \times v^2/2g$, in which D is the diameter of pipe, r the radius of the center line of the bend and v the average velocity in the pipe. On this basis the greatest loss of head would be from a bend of the smallest radius, and the longer the radius the less the loss would be.

Experiments by Williams, Hubbell and Fenkell at Detroit on pipes of 12, 16 and 30-in. diameter, however, indicated that the loss of head was a minimum for bends with radii of about 2½ times the diameter of the pipe and that the loss did not in all cases vary as the square of the velocity. Further experiments made by Schoder at Cornell on 6-in. pipe, by Davis at the University of Wisconsin on 2-in. pipe, and by Brightmore in England on 3-in. and 4-in. pipe showed that the Weisbach formula did not hold for larger pipes under ordinary conditions of service. These later experiments, however, did not confirm the Detroit experiments as to the minimum loss occurring with bends of a radius of 2½ pipe diameters. The relation of velocity to loss for all these experiments ranged from $v^{1.2}$ to $v^{2.73}$.

As these experiments were all carefully made under conditions sufficiently uniform to justify the expectation of at least an approximate agreement, they offer the best basis that we have of obtaining the loss in bends.

Effect of the Radius

In the discussion of these experiments it seems to have been assumed that the loss of head in bends on different sizes of pipe should be the same when the radii of the bend in terms of the diameter of the pipe were alike. With so many different factors contributing to the loss there seems no reason to assume such a relation. It seems better to accept the experiments as they stand, adjusting the conclusions to the data, rather than to assume that some of the data are in error simply because they do not satisfy the assumption. Fig. 1, giving a plotting of the data on the basis of the radius in pipe diameters, and Fig. 2, indicating a plotting on the basis of the

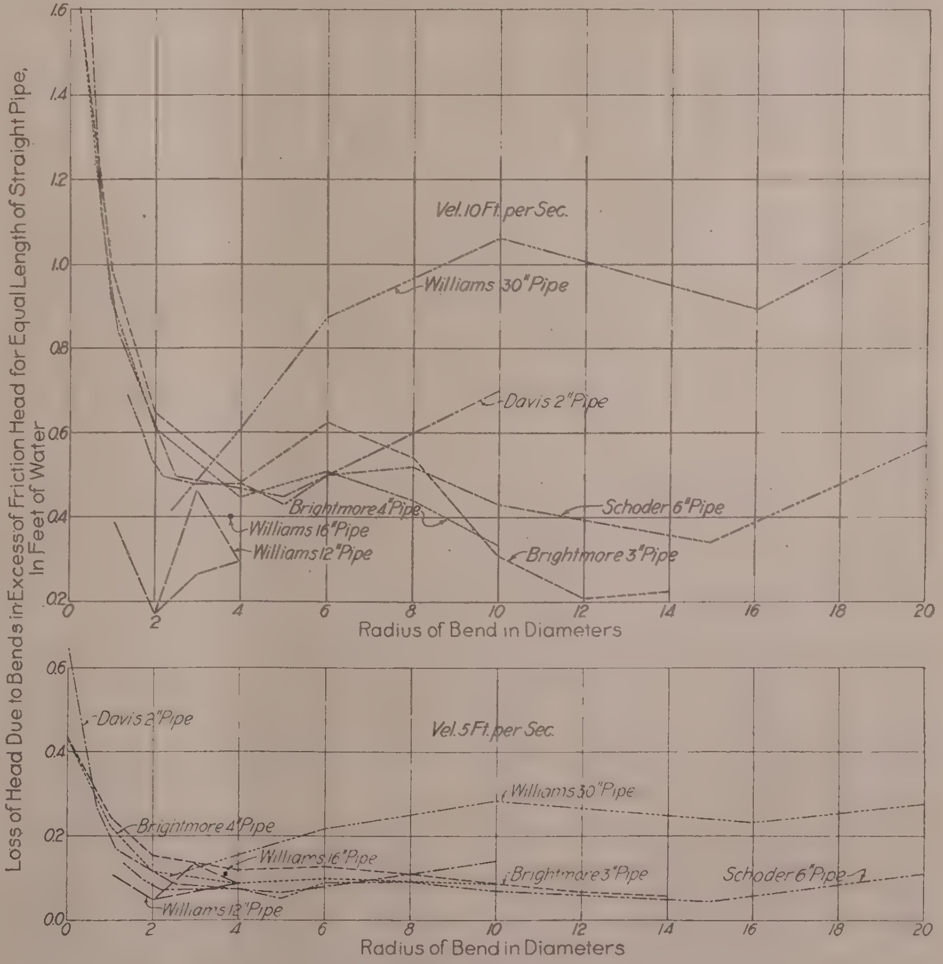


Fig. 1—Loss of Head Plotted on Basis of Radius in Pipe Diameters

radius in feet, shows that the loss is more nearly the same for different sizes of pipes with bends of the same actual radius in feet than for bends of the same radius in pipe diameters. In Fig. 1, while the curves representing the losses in bends of diameters from 2 in. to 6 in. agree fairly closely, those for larger pipe are very different. In Fig. 2 a much closer agreement between the small and large pipe curves is obtained.

It is probable, according to Mr. Fuller, that neither of these diagrams is on the correct basis and that the actual relation between the loss of head and the radius is a more involved one. Possibly the inner radius or the outer radius of the bend should be used for the comparison instead of the radius of the center line; or it may be that both *r* and *D* are involved in some more complicated form. However, in Fig. 2 the average curves drawn fit the data approximately and may be used for obtaining the probable loss of head in bends.

From Fig. 2 average curve values of the loss of head for different velocities due to bends of the same radius were plotted on logarithmic paper in relation to velocity. From these plottings the relation was established that the loss of head is proportional to $v^{2.25}$. On this basis a formula for loss of head may be stated as $h_b = kv^{2.25}$, in which k is a coefficient varying for bends of different radii and h_b is the loss of head in excess of the loss in a straight pipe of a length equal to the length of the curve. Fig. 3 gives the values of k for bends of radii up to 60 ft. This relation between h_b and v is an average relation and may be changed by further experiments.

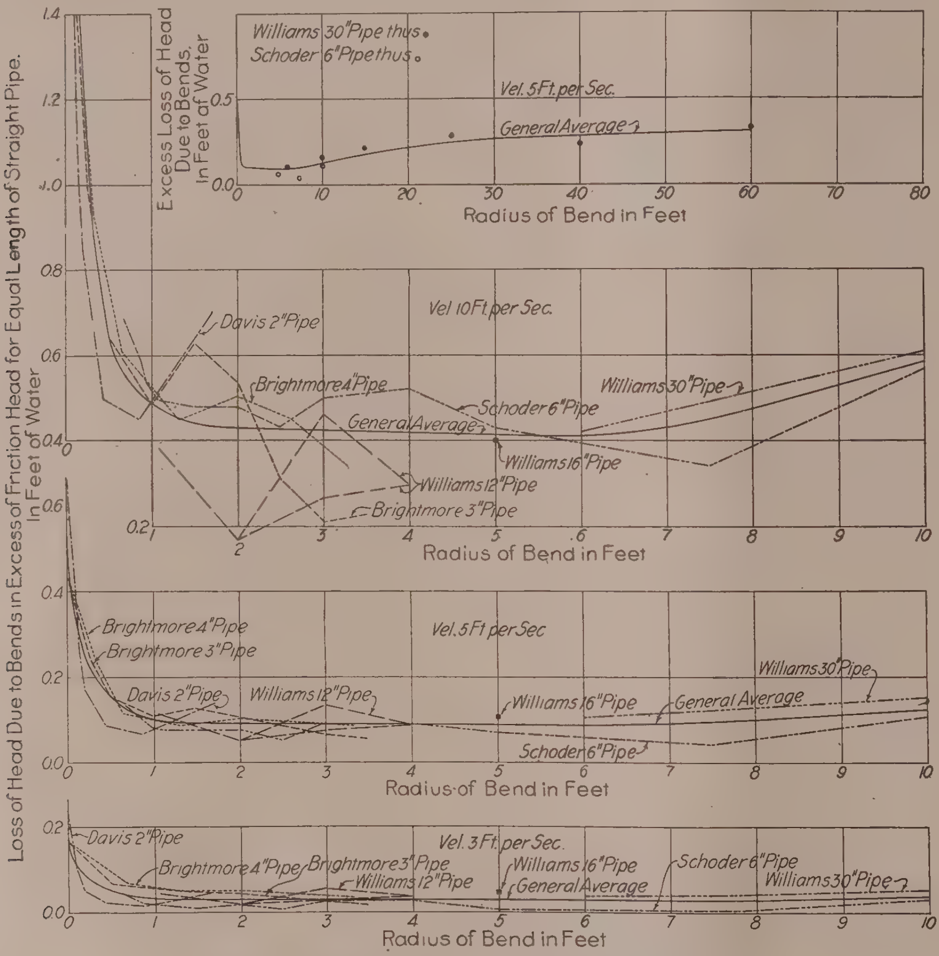


Fig. 2—Loss of Head Plotted on Basis of Radius in Feet

The correct use of Fig. 2 involves taking into account the relative length of the different curves, as the length governs the proportional friction. The friction varies as the roughness of the pipe, so it is most convenient to compute the loss of head in pipe lines by taking the actual lengths of the tangents as straight pipe, finding the frictional resistance and then adding the excess resistance due to curves and other specials.

Fig. 4 is drawn to meet this requirement. The loss due to the curve is taken from the average curve in Fig. 2. The friction in straight pipe of a length equal to the difference between the length of the tangents and the length of the curve is then deducted. The frictional resistance in straight pipe is taken according to the Hazen-Williams formula, with $c = 100$. This coefficient obtains for average pipe that has been in use for some years, thus probably meeting requirements, as the loss in bends is greatest when the pipe is used at its maximum capacity. For new pipe well laid this excess loss in head would be somewhat greater; for pipe in very bad condition it would be less.

Fig. 4 shows the following points: (1) The excess loss of head in bends is greater for large pipes than for small ones. (2) For large pipes a 6-ft. radius bend gives the least resistance, unless very long radii are used. (3) If the radius can be made very long, the least resistance will evidently be from the bend of greatest radius. (4) For small pipes, at least, with long radii the loss of head will be less than it would be in straight pipe of a length equal to the tangents of the curve. This occurs when the saving in friction head due to shorter line becomes greater than the excess loss due to the bend.

The accompanying table has been prepared on the same basis as Fig. 4, giving the excess loss for bends made according to the New England Waterworks Association standard.

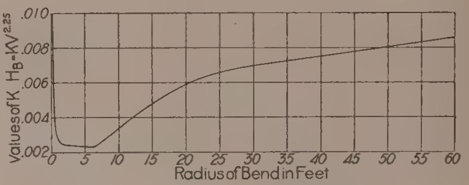


Fig. 3—Values of Coefficient, k

For most lines of small pipe economy or convenience in laying will govern the selection of the bend, though the use of very sharp bends should generally be avoided. For large pipes the losses in bends are far more important for several reasons. First, the actual loss is greater for the larger pipes. Second, for the same velocity the frictional loss is less for large pipe than for small pipe, so that the loss in bends is a greater proportion of the total loss. Third, the amount of money involved is greater in the case of large pipe and a greater expenditure is justified to avoid losses of head.

Loss of Head Due to 90 Deg. Bends of the New England Waterworks Association Standard

Size of pipe, in.	Radius bend, ft.	Excess loss in straight pipe of length equal to tangents. $v = 3$ ft.	$v = 5$ ft.	$v = 10$ ft.
4	1.33	0.0211	0.073	0.366
6	1.33	0.0247	0.082	0.399
8	1.33	0.0263	0.086	0.414
10	1.33	0.0271	0.089	0.423
12	1.33	0.0279	0.090	0.429
16	2.0	0.0262	0.085	0.409
20	2.0	0.0269	0.086	0.415
24	2.5	0.0265	0.085	0.410
30	3.0	0.0262	0.083	0.406
36	4.0	0.0258	0.083	0.400

The importance of losses of head which occur on large pipe lines at specials and at entrances and outlets may be understood when it is realized than in 1000 ft. of 72-in. pipe a single 90-deg. bend poorly designed may readily reduce the capacity of the line by 5 per cent, and a poorly designed inlet or outlet of the pipe to a structure may reduce the capacity by fully 10 per cent.

As to bends under 90 deg., Mr. Fuller suggests the use of the following values for loss of head: 45-deg. bends, use three-quarters that due to 90-deg. bends of same radius; for 22½-deg. bends, one-half that due to 90-deg. bends of the same radius; for a Y-branch, three-quarters that due to a tee.

The loss of head in bends for velocities of 3 to 6 ft. is approximately proportional to the velocity head $v^2/2g$, and for rough approximations the following rules will serve: For 90-deg. bends of a radius in excess of 1½ ft. and less than 10 ft., $h_b = \frac{1}{4}\ (v^2/2g)$; for tees (bends of zero radii) $h_b = 1\frac{1}{4}\ (v^2/2g)$; for sharp 90-deg. bends of 6-in. radii, $h_b = \frac{1}{2}\ (v^2/2g)$.

Further experimental work adding to the data on the loss of head in bends of large diameter would prove of the greatest service.

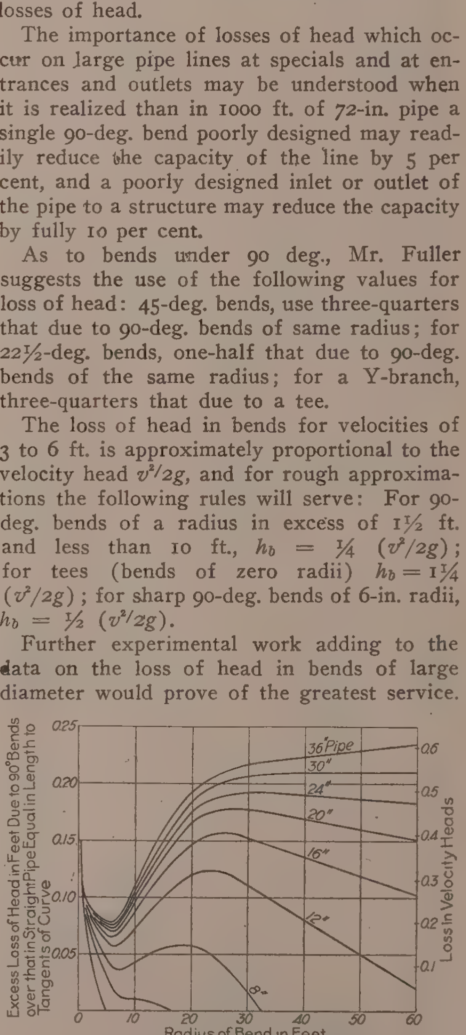


Fig. 4—Losses for Large and Small Pipes

Calculated on basis of $v = 5$ ft. per second and $c = 100$ in Hazen and Williams' formula.

Design of Large Bridges, with Special Reference to Quebec Bridge—Part III

Paper by Ralph Modjeski, Consulting Engineer, of Chicago, Presented before the Mechanical and Engineering Section of the Franklin Institute, Philadelphia

Bottom Chords.—The bottom chords of the anchor and cantilever arms and their details were the subject of a great deal of study and of many tests. Little is known about bridge compression members when compared to tension eyebars. The Quebec compression chords are members of unusual size. It is only in work of great magnitude that the engineer has an opportunity to make tests on a large scale; the expense of such tests is trifling in comparison with the importance to the structure of the results obtained. It is not sufficient to know that in some bridges a compression member is still standing and is subjected to a certain stress. What we should know is how much greater stress it would take to destroy that member. Such a member may be in the stage of danger from the last straw. The board made a number of tests on models of chords and posts, both for the official design and for the final one. The tests gave generally better results for model members representing the latter. The board feels, therefore, that a good design for these heavy members has been obtained.

There never was any serious doubt among the members of the board as to the advisability of making the bottom chords of the anchor and cantilever arms riveted throughout without pin joints, except at the main pier bearings, to avoid excessive secondary stresses. This was done and will result in a stiffer bridge.

Top Chords.—The original design as submitted by the St. Lawrence Bridge Company contemplated top chords built of plates entirely. While this was approved at the time, later studies proved that by building the top chords of carbon steel eyebars there will be a slight saving of weight and cost, and the change was authorized. A tension member built of eyebars is the most reliable type by reason of the large number of full-size eyebar tests which have been and are constantly being made. It is the logical form of construction for transmission of tensile stresses. Their use reduces the secondary stresses. In a chord built up of wide plates with riveted joints, making it continuous, the secondary stresses resulting from bending due to the deflection of the span would be considerable, but owing to the uniform deflection of the "K" design they could easily be taken care of.

One of the guiding principles of the designers of the new Quebec Bridge was the elimination of untried features and experiments. In a span of this length some new features must necessarily be introduced, but they are limited to those only which grow out of the unprecedented length of span.

Suspension Bridges.—With the length of the Quebec span of 1800 ft. and with the materials now at the disposal of the engineer, the practical limit of cantilever construction has very nearly been reached. In fact, if economy alone is to be considered, a cable suspension bridge would have been cheaper for a span of 1800 ft. The cantilever structure presents a greater rigidity under moving load, and this greater rigidity was the determining factor in the decision of the board to adhere to the cantilever type. Tentative plans of the suspension type with wire cables were, however, partly worked out by the board in the way of study.

The comparative rigidity of the cantilever system on one hand and the suspension type on the other may be gaged by the deflections at the center of the span under full load.

Deflections at Span Center, Full Load

New Quebec span, total live load	11¾ in.
Cable suspension bridge, trial design—live load only, over	2 ft.
Cable suspension bridge—with 120° variation in temperature and full live load—between highest and lowest positio, about	7 ft.

There are two reasons for the large deflections in suspension bridges—first, the deflection due to variations of temperature in the cables of a suspension span, which in a cantilever span is inappreciable; and, second, the fact that higher unit stresses are permissible in the wires of the cable than in the members of the cantilever span. The working unit stress in the wires is generally taken at from 55,000 to 60,000 lb., while less than one-third of this is permissible in rolled carbon steel.

Moving Load

When a moving load travels on a suspension bridge it subjects it to partial deflections which may be compared to a wave motion. This motion is greatly obviated by the use of deep stiffening trusses. The deeper those trusses are, the smaller will be the partial deflections. It is, therefore, an advantage to make these stiffening trusses as deep as practical considerations will permit. But, on the other hand, the deeper the truss the more equalizing will it perform and, therefore, the heavier will it have to be. Each particular case must be studied in this respect, taking into consideration the relative importance of the live load which produces these local deflections to the dead load. A suspension bridge generally consists of one main span and two side spans. There are two distinct types of side spans—one where these side spans are suspended from the cables, as in the Manhattan Bridge in New York, and one where they are supported independently of the cables, as in the Williamsburg Bridge in that city. There are also two types of stiffening trusses for the main span—a continuous truss, as in the Manhattan Bridge, and a truss hinged at one or more points, as in the Brooklyn Bridge. For a bridge for highway and street car traffic, even though interurban trains are to use it, the most suitable type is the one with comparatively shallow stiffening girders continuous over the main span, with side spans suspended from the cables: this because of the absence of concentrated moving loads which would be heavy enough to cause appreciable local deflections. On the other hand, a bridge for railroad use, single or double-track, should preferably be built with deep stiffening trusses over the center span, hinged at center or continuous, with side spans supported independently of the cables. It is perfectly practicable to build an efficient and economical suspension bridge for railway use if these principles are adhered to.

The main parts of a suspension bridge are the cables. These are sometimes replaced by eyebar chains. The longest eyebar suspension bridge is in Budapest and has a span of 981 ft. The longest cable span is 1600 ft., and the one built by Roebling Brothers is still giving excellent service. There is no doubt, therefore, that the wire cable has been successful for long spans. It is doubtful if an eyebar chain suspension bridge of 1800-ft. span would prove economical as compared with the cantilever type unless some special steel with which we have had little experience be used. The impact from moving load in the chain would be within 10 per cent of the impact produced in the top chords of the cantilever arms, so that much higher unit stresses in eyebar chain links than those used in eyebar top chords of the cantilevers would not be justified. The allowable working stress in cables is not less than 55,000 lb. per square inch, while it is not over 30,000 lb. in nickel-steel eyebars, or a little more than one-half.

Span Limits

From what was said throughout this paper it is obvious that the longer the span the greater the need of materials of high resistance. For plate girders and short spans ordinary medium steel does very well and is used exclusively; for longer spans, beginning with 400 ft. alloy steel, such as nickel steel, nickel chrome, vanadium, etc., may be used to advantage, this advantage increasing with the length of span. The practical limit of cantilever system for known materials is reached at about 2000 ft. for a railroad bridge. For longer spans, suspension bridges should be used, and are made possible by the high resistance of wire cables. The practical span limit of a wire cable suspension bridge has been calculated at 4335 ft., assuming a working stress in the cables of 60,000 lb. per square inch.

The breaking load of the cables was assumed at 180,000 lb. per square inch. If an alloy wire be used of a still higher resistance the practicable limit will exceed the one given above. The limit of length of a cable alone without any load except its own, stressed at 60,000 lb. per square inch, is 15,160 ft. This assumes the versed sine of the cable to be ⅛.

An eyebar chain of alloy steel, such as now in use, should not be stressed beyond 30,000 lb. per square inch. Assuming this stress and a versed sine of ⅛, the limit of length of such a chain will be 7010 ft. Hence, the limit of span length of an eyebar chain suspension bridge to carry live loads would be considerably below that of a cable suspension bridge.

The suspension design lends itself better to graceful treatment than a cantilever bridge, and may often be preferred for ornamental highway bridges even where a cantilever would make a cheaper bridge.

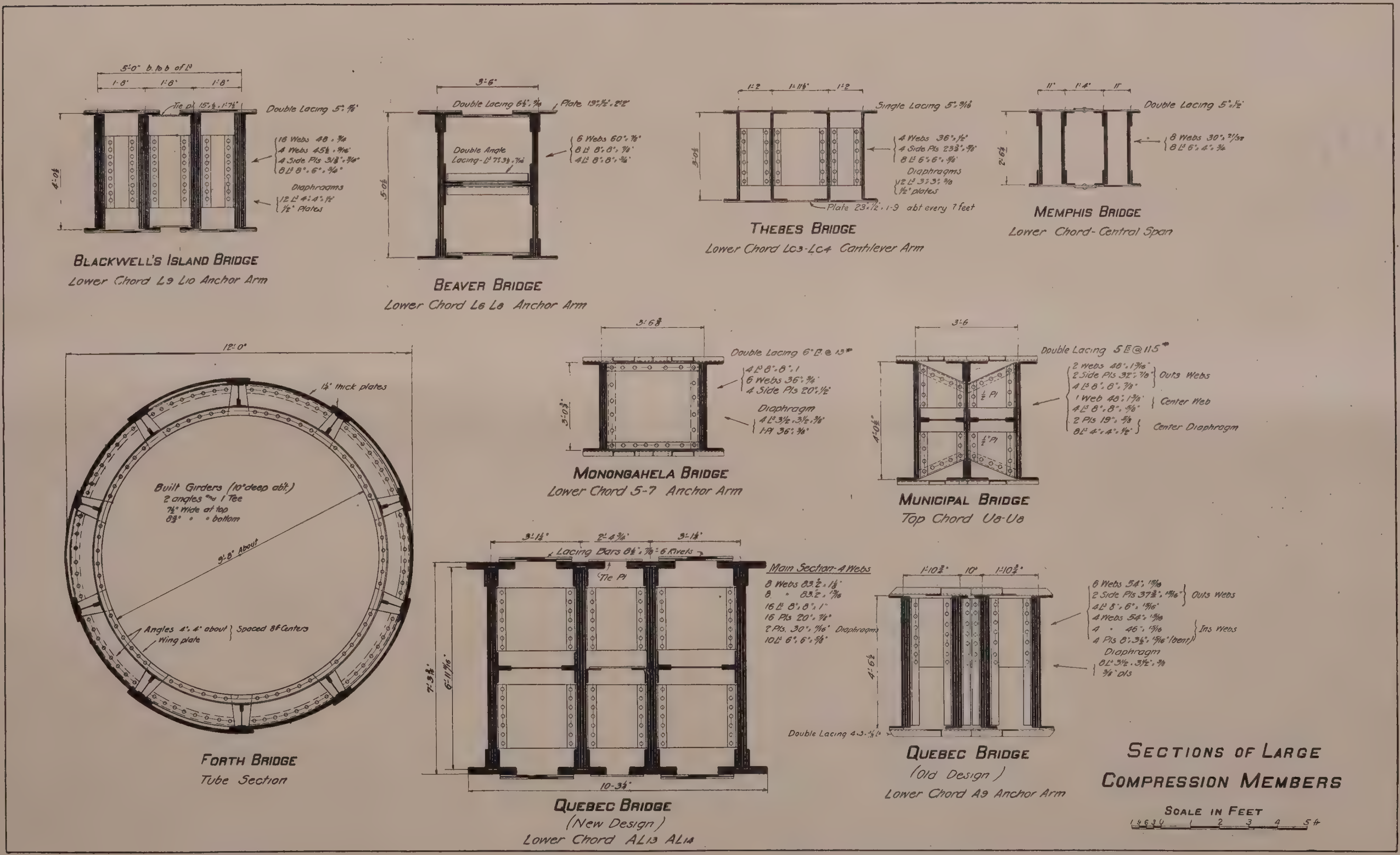
Considering the purely utilitarian structures, such as the majority of railroad bridges, the present knowledge of metals and its alloys, and the present loadings, we may sum up the various types of large bridges as follows:

For spans up to 750 ft.	Simple spans
For spans from 650 ft. to 2000 ft.	Cantilever spans with suspended span.
For spans from 1500 ft. to 4000 ft.	Cable suspension spans.

Arch spans have their place only where natural conditions are favorable, or for ornamental bridges.

Chain suspension bridges may be used for ornamental highway or city bridges, but for railroad service and for spans below 1500 ft. the cantilever is to be preferred as giving a stiffer and generally a cheaper structure.

It will be noticed that the above limits overlap. Local conditions in each particular case will be considered in deciding whether a span between 650 ft. and 750 ft. should be simple or cantilever, or whether a span between 1500 and 2000 should be a cantilever or a suspension span.



Typical Cross-Sections of Principal Iron and Steel Compression Members in Cantilever Trusses of the Longest-Span Railroad Bridges

Secondary Stresses.—I shall not dwell long on this latest addition to bridge calculations. That secondary stresses exist is a fact. They may be from three sources: First, weight of member; second, temperature; third, bending from loads.

In the new Quebec design all secondary stresses were calculated and taken care of, but as a result of tests made by the Quebec Board, the stresses in tension members due to their own weight will be neglected. It is quite possible that if similar tests could be made for other secondary stresses it would be found that the metal adjusts itself to a large extent in such a manner as to reduce the importance of those secondary stresses and their influence on the elastic limit of the member. Personally, I feel there is a tendency at present to overrate the importance of secondary stresses. They should, of course, be considered in designing a structure; it should be the aim of the designer to reduce these secondary stresses to the minimum, but excessive refinement should be avoided, and unit stresses for direct loads should be made low enough to include these secondary stresses where they may exist.

MATERIALS

The proper selection of materials for a structure is an important part of the design. The ordinary commercial steel will do for rough plate girder work, but for large bridges a metal of higher quality should be used. The metal or alloy should have a high elastic limit, a high ultimate stress, and possess sufficient ductility, which is characterized by the elongation and the reduction of the cross-section of specimens tested, to allow its being worked in the shops without fear of injury. Here, perhaps, climatic conditions should be mentioned. Intense cold makes steel brittle. This is shown by the greatly increased number of rail fractures during severe winters. The use of high carbon steel should therefore be avoided in northern climates. The behavior of the various alloys in freezing weather needs yet to be studied.

In all that precedes I have endeavored to avoid speaking of matters which are usually given in text-books. I have also avoided mathematical deductions, leaving them to better mathematicians, and I have attempted to deal with this vast subject from a practical standpoint only. When the final report of the Quebec Board is published it will give in detail what I have merely been able to outline. Numerous most interesting tests and mathematical analyses have been made and will be published in the course of events. It will then, perhaps, be realized, even by the members of the engineering profession who had no opportunity to design a very long span, that, while it is very easy to draw a diagram and a few of the principal details, it takes months of study, of retracing one's steps, of tests and calculations, to make a complete design and to learn that the preliminary diagrams and sketch details must often be changed entirely to make a practicable and an efficient structure.

Prismoidal Formulae to Suit Special Cases

For the letter to the editor under the above heading on page 140 of the Aug. 2 issue the equation (3) was incorrect. In the second term from the end the coefficient K was used instead of K_3. The equation as it appeared in the original copy should read

$$y + z = K_1 + (a + K_2)\,x + (b + K_3)\,x^2 + c\,x^3 \qquad (3)$$

In the sentence following this equation the constant K is used again, where it should have been K_1.

Proposed Water Supply for Winnipeg

A plan for permanent works carrying water from Shoal Lake to Winnipeg, Manitoba, 95 miles away, has been approved by the city council. The project, which was recommended in the report submitted by Messrs. Rudolph Hering, Frederic P. Stearns and James H. Fuertes, constituting the board of consulting engineers, will take five years to complete, the estimated cost being more than $13,000,000. Record progress in the adoption of a project of such magnitude is claimed and the following dates are submitted to substantiate these claims: The consulting engineers' report, dated Aug. 20, 1913, was read to the officials of the Greater Winnipeg water district on Aug. 29, adopted by them on Sept. 6 and by the City Council on Sept. 8. The matter was submitted to the voters on Oct. 1. A summary of the consulting engineers' report follows.

QUANTITY OF WATER REQUIRED

The population of the Greater Winnipeg water district is about 225,000, about 200,000 being in the city of Winnipeg. The rapid growth is shown by the fact that the present population is twice that of seven years ago and five times that of fifteen years ago.

The daily per capita consumption in 1912 was 56.4 U. S. gal. and shows a constant increase, which is likely to continue until the consumption is double the present amount, if the present meter system of selling water is continued, or a much larger quantity if not. It is believed that 102 gal. per inhabitant is a proper quantity to adopt for estimating the future needs of the district as an average for the year, but in some months the rate will average as high as 120 gal. per inhabitant. Therefore an aqueduct to provide for a considerable time in the future should be designed with a capacity of 120 gal. per inhabitant, and even with this provision a large reservoir should be built near the city in the future to provide for a still higher rate of water consumption during short periods.

The structure recommended for conveying water for the greater part of the way from Shoal Lake to Winnipeg is a concrete aqueduct 84.73 miles long, laid with a continuous downgrade; and as it can be built of large capacity for a moderate additional cost, it has been designed to carry 102,000,000 gal. in twenty-four hours, sufficient, on the basis assumed for a supply throughout the year, for 850,000 inhabitants.

From the point near Transcona, where the concrete aqueduct ends, to the existing McPhillips Street reservoirs a 5-ft. pipe is recommended. A single pipe line of the sizes which now seem desirable will convey by gravity 30,000,000 gal. of water in twenty-four hours, or nearly three times the quantity of water now used. When necessary the flow through this pipe can be increased by pumping, or a second pipe can be laid. The Red River will be crossed by a cast-iron pipe tunnel.

Assuming a continuous growth for the Greater Winnipeg water district based upon the past growth of the district and the rate at which other somewhat similarly situated cities have grown, the 102,000,000-gal. aqueduct would have sufficient capacity for supplying the district until 1944. Assuming, further, the introduction of water from Shoal Lake at the earliest practicable date, the aqueduct would supply the requirements of the district for about twenty-five years after its completion, and the 30,000,000-gal. pipe line would supply by gravity the quantity of water required for two or three years; but as already stated, the capacity of the pipe line can be increased by pumping.

The water is to be taken from the west end of Indian Bay, as the depth and the shore conformation are favorable. It is proposed to take the water out of the lake by gravity.

The engineers recommend that a storage reservoir, not included in the plan, to hold 300,000,000 gal. and to cost $300,000 or $400,000, be built 1 mile east of Transcona and that a main pumping station be established there.

QUANTITY AVAILABLE FROM SHOAL LAKE

Shoal Lake, northwest of Winnipeg, has a drainage of about 360 sq. miles and a water surface of 107 sq. miles and is at the same level as the Lake of the Woods, with which it connects at Ash Rapids. Shoal Lake, if separated from the Lake of the Woods, would derive its supply from the rainfall upon its drainage area. The rain which falls upon the surface of Shoal Lake is offset in part by the evaporation from the lake; but under all ordinary conditions there is probably a considerable supply to the lake from the excess of the rain over the evaporation. A part of the rain which falls upon the land surrounding the lake is lost by evaporation from the surface of the ground, but such evaporation is not as great as from the lake surface, so that there is a larger yield of water per square mile from the land surfaces.

Shoal Lake is so large that in case the supply to it in any year were unusually small water stored in it in previous years could be used to make up the deficiency. For example, the quantity of water in a single foot of Shoal Lake is equivalent to about 8.5-months' supply for 850,000 people, at the per capita rate of water consumption before stated.

Though the average rainfall upon Lake Superior, 26.5 in., is 3 in. more than that on Lake Shoal, the evaporation from whose drainage area is also probably the greater, there is little doubt that the Shoal Lake drainage area will furnish from one-half to two-thirds as much water per square mile as that of Lake Superior, and upon this basis the yield of Shoal Lake in the minimum year would be between 70,000,000 and 93,000,000 gal. daily.

Those who have examined the flow of the Winnipeg River report that at Point du Bois the minimum flow recorded in the driest part of the year has been at the rate of 0.3 sec.-ft. per square mile of drainage area, and this figure applied to the drainage area of Shoal Lake would give a minimum daily flow of 59,000,000 gal. per day. The average for the driest year would be considerably in excess.

An aqueduct provided to maintain the supply during the months of highest water consumption necessarily runs at less than its full capacity during the remainder of the year, and an 85,000,000 gal. aqueduct when used at the highest practicable rate would not be able to supply water continuously to a larger city than would require an average of 75,000,000 gal. daily. It will, therefore, be seen that Shoal Lake separated from the Lake of the Woods would supply during the driest periods a large part, if not the whole, of the water which the aqueduct would convey to Winnipeg.

QUALITY OF WATER IN SHOAL LAKE

Examinations of water taken from Shoal Lake show that it is practically free from contamination, that it is clear, without odor, practically without color and has an agreeable taste. It is very soft in comparison with the water at present supplied to Winnipeg and is well suited for boiler and general manufacturing purposes.

Microscopic examinations of the water show, as is the case with the water of all lakes and reservoirs, that it contains a variety of minute animal and vegetable organisms, which can be discerned with the microscope, some of them with the naked eye. The total number of organisms per cubic centimeter ranged from 249 to 1776 and averaged 833, which is not more than the amount usually found in small lakes and the better class of reservoirs. Sometimes, though usually not in large lakes, these minute organisms increase greatly in numbers and give the water a disagreeable taste. However, the absence of complaint from cities using Great Lakes water, together with the results of recent observations and all of the conditions, indicates at Shoal Lake that troubles from bad tastes and odors should be infrequent, and not very serious, if they occur at all.

Should it ever become desirable to filter the water, either completely or to the more limited extent required to remove the microscopic and larger organisms, this can be provided for at the site of the proposed reservoir east of Transcona, where an opportunity is also presented for the aëration of the water, should this be found advantageous.

ESTIMATES OF COST

Detailed estimates of the probable cost of construction, excluding land acquisition, installations of branch pipes to adjoining communities along the line, water damages, interest charges, etc., are summarized in the report as follows:

ESTIMATED COST OF PROJECT

85 miles construction railway	$1,020,000
Clearing	55,000
Ditching	90,000
Telephone line	25,000
12,000 lin. ft. of 4-ft. cast-iron pipe from McPhillips Street reservoirs to Victoria Park at $23.17	278,000
900 lin. ft. tunnel under Red River, including shafts and 5-ft. cast-iron pipe laid in shafts and tunnel, at $144.44	130,000
43,200 lin. ft. of 5-ft. steel pipe, extending from easterly shaft of the Red River tunnel to junction with the concrete aqueduct about 1 mile east of Transcona, at $20.74	896,000
447,300 lin. ft. concrete aqueduct, extending from end of steel pipe to Indian Bay, with all appurtenances, at $19.51	8,729,000
Falcon River diversion	121,000
	$11,344,000
Add for administration, engineering and contingencies 15 per cent	1,701,600
Total estimated cost	$13,045,600

The annual cost of maintenance of the aqueduct and the expense connected with its operation is estimated at $40,000.

Unit Costs of School Buildings

Total costs of forty-seven school buildings in Boston are given in the annual report of the Schoolhouse Department, and from these figures the cubical contents and the number of pupils accommodated, costs per cubic foot and per pupil are derived. The total costs range from $23,000 to $329,000, the number of pupils per school varying from 160 to 1832. The costs per cubic foot are very uniform, averaging between 22 and 23 cents, two running as low as 17 cents and one as high as 28 cents. The costs per pupil fluctuate more widely, ranging from $117 to $208, exclusive of several high school and normal school buildings, in which the cost per pupil is as high as $940. The figures are further divided into the building proper, heating, plumbing and electrical equipment. The buildings proper cost from 76 to 86 per cent of the whole, the heating from 6 to 15 (most of them being from 8 to 11 per cent), the plumbing 4 or 5 per cent, except in a few cases as low as 3 or as high as 9, and the electrical equipment slightly less.

Impressions of European Sewage-Treatment Methods

The approaching need of comprehensive sewage-treatment works to relieve conditions in the Schuylkill and Delaware Rivers and other streams which receive polluting matter from Philadelphia's sewerage system influenced the city administration to investigate conditions in European cities. As Philadelphia's representative Mr. George E. Datesman, principal assistant engineer of the Bureau of Surveys, visited Europe and made studies of the systems of sewage treatment in cities of Germany, Austria, Holland, Belgium, France and England. His conclusions, as stated in the report which he submitted shortly after his return to the United States, follow:

CONCLUSIONS

Study of European sewage-disposal works is valuable as reflecting conditions which may exist in the United States twenty-five years hence. The establishment of government rivers boards to supervise sanitary conditions and works proposed is essential to proper results. The art of sewage disposal apparently has stopped at percolating filters, but an adequate and less costly substitute is anticipated. It is practicable to obtain from properly designed and operated sewage works a clear, odorless, sparkling and non-putrescent effluent from a sewage of extreme concentration, even if it has become septic.

Sludge resulting from sewage treatment can be rendered innocuous, practically inodorous and wholly unobjectionable and can be disposed of without nuisance, sometimes profitably. By certain combinations of treatment desired results may be secured at a fraction of the cost of other recognized scientific methods of treatment in satisfactory operation.

In the conservation of a water supply sewage-disposal systems should bear only their proportion of the cost of treatment. The construction of a properly designed, economical and sanitary collection system is the first essential in sewage disposal.

The use of the separate system of sewer conduits is inadequate and has been abandoned for urban districts. Combined systems are the most effective in urban areas, where all the polluted liquids during dry-weather flow can reach the disposal works. Polluted streams can be made pure by a system of interceptors to prevent sewage from reaching the streams. To properly construct these interceptors and their connections calls for the highest designing and constructive skill.

Rivers may be made clean and nuisances to sight and smell may be prevented by simple screening or by screening and tankage treatment, provided the diluting volume of river flow and its velocity are sufficient to prevent deposits. Rivers act as oxidizing agents, so that even raw sewage, which may have reduced the dissolved oxygen content of the streams, does not permanently pollute them. After a few miles the river reabsorbs oxygen and recovers. Where not used as a water supply the extent to which a river may be used thus offers a problem to be determined.

At the present stage of the art there is no process that gives better tankage results, better sludge digestion without odor or nuisance, or cheaper sludge disposal than the form of tank used at the works of the Emscher Genossenschaft in Germany. Should screening be desired, the so-called Reinsch screens as used at Dresden, Germany, are the most cleanly and efficient of any observed. It has been proved by experience that adequate tankage treatment is more effective and less costly than the operation of fine screens.

Of the bacterial treatments, the percolating filter furnishes the best results both in oxidizing the organic matter and in the removal of putrescibility. The speed of operation is greater than by any other system, with consequent reduced first cost for land areas.

When sufficient fats are present in the sewage they may be profitably recovered from sludge. Drying for fertilizer and fuel use has also proved profitable in some cases.

The advisability of employing percolating filters on areas of such magnitude as would be required in Philadelphia is questionable, as that course is without a precedent. Lacking anything better at present, it may be held to tentatively.

Submerged outlets from disposal works are essential for proper dilution. Disinfection with hypochlorite of lime as a final treatment is not in use either in England or Germany. In the conditions of the rivers in the former country it would not be effective in removing pollution.

It is fallacious to adhere to a policy of constructing at once an ideal sewage-disposal system. It should be practical and efficient under final conditions and should advance thereto by gradations determined by the conditions in the river which receives the sewage effluent.

New School for Health Officers

The School for Health Officers to be conducted jointly by Harvard University and the Massachusetts Institute of Technology, as noted in the Engineering Record for July 5, will be inaugurated this year.

Graduates in medicine of Harvard University and of other recognized medical schools are eligible to be registered as candidates for the new certificate, as are bachelors of science in biology and public health of the Massachusetts Institute of Technology and other recognized institutions. Applicants holding technical degrees or possessing unusual experience will also be admitted, though they will be required to perform preliminary work covering at least one year.

The course is elective, the student being privileged to choose, with the approval of the administration, from a list covering these fundamental subjects: Anatomy, physiology, pathology, biological chemistry, sanitary biology, preventive medicine and hygiene, and sanitary engineering. In addition to the studies already furnished by the Harvard Medical school or the Massachusetts Institute of Technology, sanitary engineering Department, special courses will be given by instructors not otherwise connected with either institution.

At least one year is required to complete the course. A general oral examination will be given each candidate before graduation.

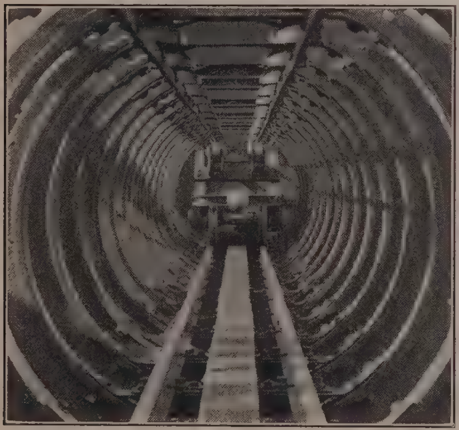
The administrative board consists of William T. Sedgwick, Sc.D.; Milton J. Rosenau, M.D., and Prof. George C. Whipple, M. Am. Soc. C. E. Dr. Rosenau is the director of the new school.

NEW YORK CITY'S FIRST OFFICIAL MAP is being prepared by the topographical bureaus of the five boroughs. Sheets scaling 600 ft. to the inch are to be assembled in the office of the chief engineer of the Board of Estimate, ultimately making possible the publication of a map of each borough.

New Electric Carrier for Mail or Package Freight

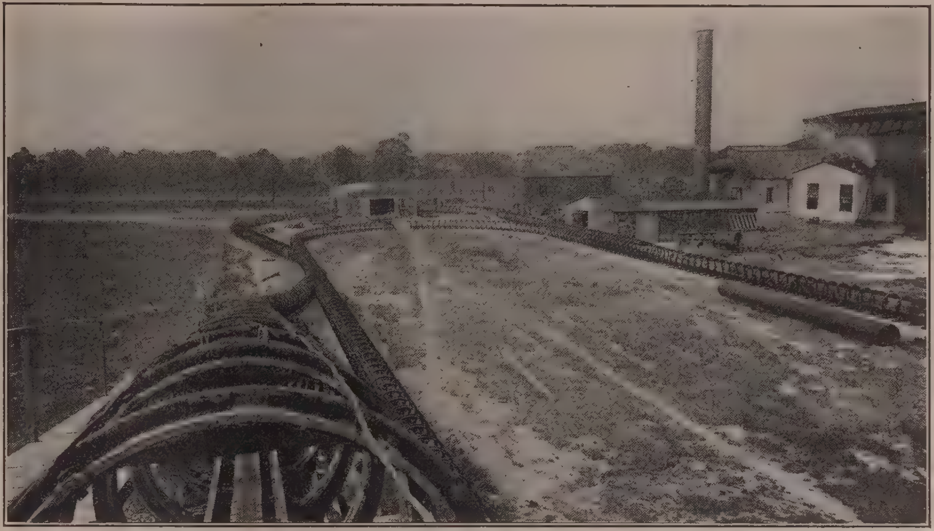
A new type of electric carrier for transporting mail, express or package freight has been devised, in which the cars, running in a cylindrical tube, are propelled by magnetic force without wheel traction. The cars operate at practically synchronous speed, whatever the grade, making their operation on a short headway possible without danger of collision. The system is claimed to be applicable to any large-scale package transportation.

The car runs on a narrow-gage track. Between the rails is a flattened part of an alternating-current induction motor, corresponding to its rotor, with closed-circuit windings of the squirrel-cage type. On the bottom of the car is another flattened part of a motor, corresponding to its stator, with open-circuit wire windings. The air space between motor parts is about $\frac{3}{8}$ in. Power is supplied to the car through two live rails at the top of the tube. Contact is made by a small wheel running on each rail, as shown in one of the illustrations; the short stiff springs holding the trolley wheels in contact help guide the car around curves, but without binding, opportunity at the same time being afforded for the maximum height of car. The alternating current used passes through the primary member on the car and induces a magnetic field, which propels the car at uniform speed regardless of the grade. Ball bearings are used on the running wheels, which are mounted on separate axles.


Track, Tube Frame and Contact Rails

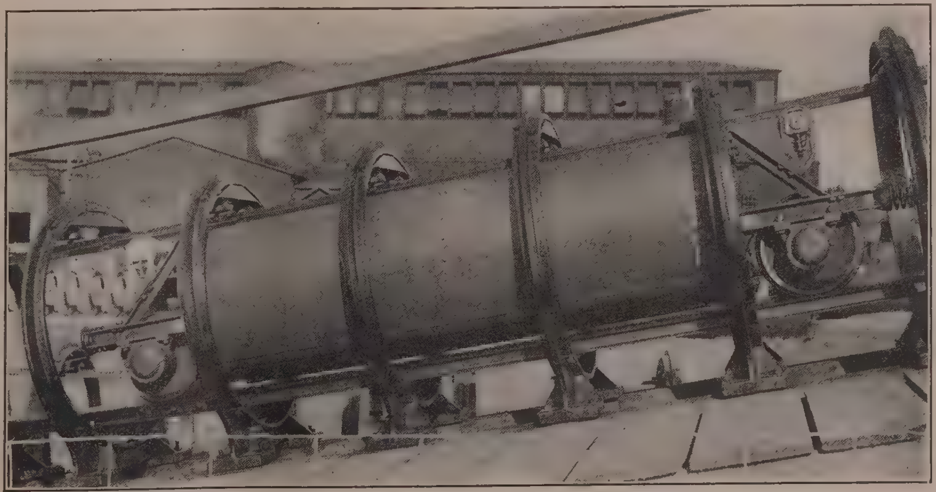
As yet there has been no service installation of the system, but for demonstrating purposes a plant has been laid out near the Vreeland Avenue station at Paterson, N. J. It consists of a level elliptical track 1000 ft. long, with a switch running up a 20 per cent incline and back to the main track, and another running through the terminal building. The tube is 3 ft. in diameter, the ribs being uninclosed most of the way to permit observation of the system. The track has a gage of about 11 in., and is laid with 16-lb. rail. The car body is 5 ft. 7 in. long, the over-all length being 9 ft. 6 in. and the weight 1250 lb. Power is supplied at 440 volts from a 25-kva machine. A patent signal system divides the line into several blocks, and the block occupied by the car is indicated by a light in a glass diagram of the layout in the terminal building. The switches are at present hand-operated. Stopping of the cars is accomplished by reversing the current, assisted by a pair of raised rails at the terminals which brake on the bottom of the car body.

In a recent demonstration a car ran around the track, whether by the level route or by the detour over the 20 per cent grades, and whether empty, loaded with 1000 lb. or hauling a trailer weighing 1200 lb., at practically uniform speed. It was stopped and reversed at will by reversing the current. Switches, as well as curves of 40-ft. radius, were taken at the top speed of 24 miles per hour, and no tendency to derailment was shown.


General View of Track and Terminal Building from Top of Incline

It is proposed to apply the system, using 48-in. underground tubes and larger cars, wherever there is a large movement of mail or packages between points, such as in the transportation of mail between the two main railroad terminals in New York City, or in department store or express deliveries in large cities, as well as in general business between cities. The advantages claimed over any other electric system are that the same unit of power will send a car farther and faster when applied as a direct pull than when exerted indirectly through gearing; that the smallness of the propelling member increases the carrying capacity of the car; that it is adaptable to any grade, and by entering second stories can obviate extra handling of freight; that grinding of wheels is eliminated; that the smallness of wheels will not limit the speed, and that the synchronous movement will safely permit high-speed operation on a short headway. The controlling company claims that a speed of 60 miles per hour is perfectly feasible. It also claims great advantages over any other magnetic system in the use of a continuous track member and in the reversing of the primary and the secondary elements, eliminating costly winding on the long track element.

The system is patented, and is controlled by the Electric Carrier Company, whose offices are located at 220 Broadway, New York City.


Car Ascending 20 Per Cent Grade—Showing Contact Rails and Trolleys

Proposed Large Suspension Bridge

Up to the present time the Williamsburg Bridge over the East River between Manhattan and Williamsburg is considered the largest structure of its kind, with a span of 1600 ft., having six tracks, two drives and two sidewalks. In a lecture before the Liverpool Engineering Society Mr. L. H. Caase proposed the construction of a larger bridge across the Mersey River at Liverpool, and gave arguments to prove the feasibility of the scheme. The proposed bridge would have a span of 2660 ft. and a width of 50 ft.; the height above the water surface would be 200 ft., the towers being 490 ft. high. The live load on this bridge would only be a fraction of the heavy traffic that the Williamsburg Bridge has to carry. It is calculated that the bridge would accommodate about 600 cars and carriages per hour. At the towers the cables would be spaced 100 ft. apart, and they would be braced at the vertical center of the wind pressure. This would cause a slight torsion in the structure for eccentric loadings.

A noteworthy arrangement is that of the approaches, which as designed have a length of 335 ft. and form a helical curve with four and one-half windings. This helical roadway is supported on a reinforced-concrete tower of 200-ft. inside and 300-ft. outside diameter. It is estimated that the structure proper would cost about $4,000,000.

Highways of New York State

Legal, Financial and Engineering Considerations in Expending $100,000,000 for Roads

By George A. Ricker, M. Am. Soc. C. E., First Deputy Commissioner of Highways, New York

In New York State there are now 80,000 miles of State, county and town highways. Under the existing law improved highways known as State and county highways, which have been or are to be built, amount to 11,986 miles. On Jan. 1, 1913, 3578 miles had been constructed and 1627 miles were under contract, of which by Jan. 1, 1914, it is expected that 1000 miles will be finished, making 4578 miles of completed highways in the State, with 7000 miles yet to be built.

The people of New York have voted $100,000,000 for roadbuilding, the largest amount of money ever appropriated by any state for the purpose. In each of the two referendums $50,000,000 was voted, and of the first appropriations there now remains nearly $17,000,000 unexpended. Approximately all of this latter amount, however, is obligated by existing contracts for road construction and the elimination of grade crossings of railroads throughout the State.

The first issue of bonds authorized by constitutional amendment was intended for the improvement of a system of county highways aggregating more than 8000 miles in length and would, with the moneys derived from the counties as their share of the cost, have been sufficient for that purpose. There was afterward added to this mileage a system of State routes, totaling 3300 miles, the entire cost of which was to be borne by the State, and the first $50,000,000 was made inadequate for the completion of either system, as this sum was to be divided between county and State construction.

Apportionment of Funds

When the first bond issue was authorized it was apparent that some systematic method would have to be provided for an equitable apportionment of this money among the counties of the State and for the amendment to the Constitution authorizing the bond issue so directed. On account of the appropriations, which have been made for what are termed "expedited routes" and the exigencies of construction which have arisen in certain counties, some counties have received more than their equitable apportionment of the first bond issue, and it is the intention and endeavor of the present commission to correct these inequalities as far as possible with the funds remaining.

The second referendum or bond issue authorizing another $50,000,000 for highway purposes provides for an equitable distribution of this fund among all the counties. This distribution is made, first, on the basis of $20,000,000 for the construction and improvement of State highways and $30,000,000 for the construction and improvement of county highways, as defined by the highway law; these two funds are to be subdivided among the counties based on the percentage of population, mileage and area that each county bears to the total population, mileage and area of the State. The sum of one-third of each of these three factors constitutes the percentage of such equitable apportionment.

The constitutional amendment authorizing the second bond issue of $50,000,000 provides for the completion of State and county highways already laid out as described in the highway law, precluding the possibility of any additions to the existing system.

It soon became apparent that any scheme of road improvement that contemplated a skeleton system only and did not provide for the vast system of tributary roads would fail in reaching its fullest possible value to the commonwealth, so there was organized, as a part of the highway department, the bureau of town highways, to have charge of all roads not included in the State or county systems, and through this bureau State aid is given to the towns for the building and maintenance of less expensive type of roads not included in either of the two classes heretofore named.

From the above condensed statement of legislation and financial data it will be seen that all classes of roads are provided for by the highway law of New York State. The main lines provide continuous routes across the commonwealth from New York to the Canadian border and from the metropolis by several routes to the Great Lakes; county roads supply connecting links betweeen the trunk lines, and town roads give entrance into the other classes of highways for those who live in the interior districts.

General Hancock's historic phrase that "the tariff is a local issue" might be paraphrased with much accuracy to apply to road construction. In the length and breadth of the Empire State soil and even climatic conditions are so divergent that a type of road that is suitable and serviceable for one section is unfit and not adapted to another.

How shall we build to meet fairly and squarely the new demands of the motor vehicle? What types of roads and pavements will best resist the tortional stress of the hard rubber tires, the impact of the heavy loads, and the destructive attrition of the traction engine? The problem is not coming—it is here. The old water-bound macadam road so efficient and so comfortable is failing here on principal thoroughfares as it has in England and in France. Bituminous macadam has not yet demonstrated its serviceability; bare concrete in New York has generally failed; bituminous covered concrete is a doubtful success, and there are drawbacks to brick pavements besides their excessive cost.

Value of Maintenance

Comparisons unfavorable to the roads of New York State with those of other States are often made, but it is the writer's observation that, with some recent exceptions, the roads of New York are as well constructed as those of our neighbors. It seems plain that the roads in adjoining States deservedly receive praise and commendation almost solely on account of superior maintenance. Roads in New York State have been well built and left to neglect and destruction. Roads in neighb ring States have been indifferently constructed but carefully maintained, with the result that our neighbors have been fairly credited with superior knowledge of the roadbuilding art, when in fact they have only been painstaking and careful in maintaining what they had.

The problem of maintenance is probably more difficult in New York because of the lack of certain repair materials which are found in abundance in the New England States. It must be remembered also that each one of the six divisions into which the Empire State is now divided is as large or larger than most of her eastern neighbors, and it follows that our problem of maintenance is more than six times as big as theirs. The soft, friable stones of the southern tier are unsuitable for top dressing; crushed trap or limestone does not give a brilliant, velvety surface like the brown sands of western Massachusetts. The coarse quartz sand of Long Island is too far away from the northern and western sections of the State to be available.

We have been passing through a period of experimentation. While the questions of foundation have been fairly solved, the problems of drainage understood and met, the respective values of cementing agents or binders have been little understood. Petroleum and asphaltic oils responding to an infinite variety of chemical formulæ have been applied without a proper appreciation of either their mechanical or chemical action, and often the oils applied to the surface filtered through the tops and fluxed the binders designed to hold together the lower courses. In the honest endeavor to secure better results, new compounds, like patent medicines, have been applied without a clear understanding of effects.

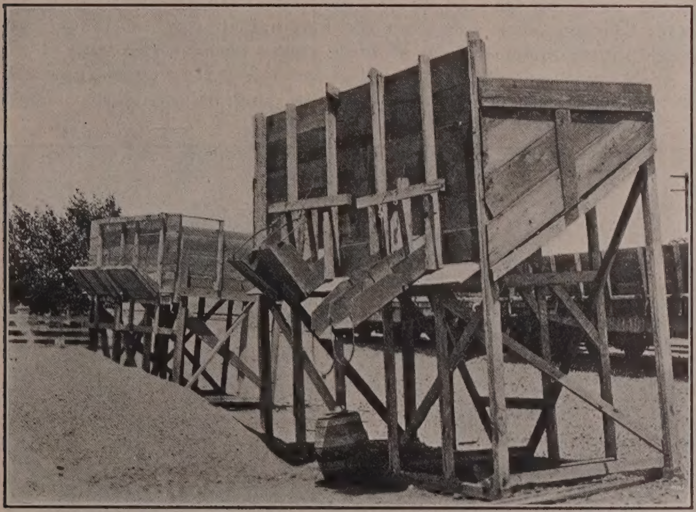
Types of Pavement

In the present state of the art of roadbuilding it seems probable that, in general, the course that shall be followed is deeper and heavier foundations for principal thoroughfares, a more careful and thorough system of drainage, and intelligent and continuous maintenance, with adherence to the best forms of macadam for county roads. Concrete may be used to advantage where soil conditions preclude other treatment, but it should be always as a foundation for some suitable top or wearing surface. After having been engaged in building many kinds of concrete structures it is the writer's opinion that concrete as a road material cannot be so protected as to insure a permanent structure. It is a truism to say that concrete, if good, is splendid stuff, but if it is poor it makes the worst kind of a structure, since it cannot be maintained in suitable condition for use and becomes a nuisance that must be removed. Permanent concrete works must have in their building infinite care in the testing and inspection of material and workmanship, such as it is practically impossible to secure in public-highway building. To obtain good concrete the ingredients must be of the very best of their several kinds, and impurities and foreign substances must be absolutely absent.

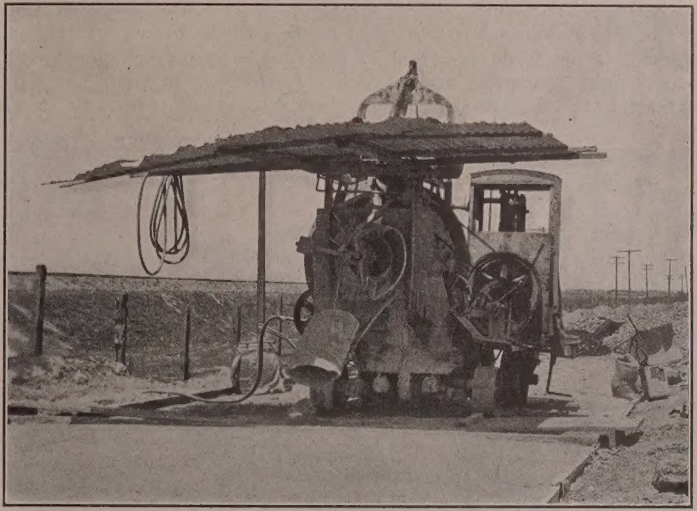
Asphaltic and brick pavements are too expensive for country roads. Even the many millions available in New York State for highway construction would go but a short distance if these materials are largely specified. The primary purpose of good-roads appropriations was to build highways connecting cities and villages and to bring the isolated settler into easier communication with the market and the centers of business activity. The appropriation of considerable portions of these funds for the pavement of city streets is outside and beyond the original intention of the authors of good roads and is manifestly unfair to the larger cities, which provide the major portion of the funds and have to contemplate their diversion to the pavement of streets in smaller cities and their subtraction from the country districts where they are so urgently demanded for the benefit of the farmer and the traveler. Roughly speaking, the money invested in 1 mile of brick pavement or sheet asphalt will build 2 or 3 miles of good country road. The order of New York State's commissioner of highways, intended to restore to the country roads the major portion of funds available for heavy construction, has been and should be recognized as a move in the right direction for the proper placing of the moneys appropriated for good roads.

Unreasonable Use of Roads

By the law of New York the commissioner of highways is empowered to make rules and regulations from time to time for the protection of all improved roads. He may prescribe the width of tires to be used and he may prohibit the use of chains or armored tires, and disobedience of these rules will be punished by fine. In this provision of the law lies the possibility of limitation of the destructive agencies of motor traffic. There is need for more durable types of construction, but there is need also for some limitations upon the unreasonable use of existing roads; so far as possible, highways must be designed to meet the demands of the traffic that will pass over them; but until the art of roadbuilding has developed to a higher level of perfection the use of roads by unreasonable loads at unreasonable speeds, with unreasonable traction, must be prevented. The efficiency of wearing surfaces must be raised, but the destructive agencies of transportation must be minimized.



Bins to Economize Loading Time of Teams



Sun-Protection Canopy over Mixer

Commissioner Carlisle has recently said: "Our State as a whole has remarkably diversified scenic features unsurpassed by any other State or country. Our improved roads as planned run for miles along the Atlantic Ocean and Long Island Sound; pass through the historic valleys of the Hudson and Mohawk rivers; cover the old Indian trail along Lake George and Lake Champlain to the Canadian border; climb the mountain sections of the Adirondacks and Catskills; follow the international Canadian boundary along the shores of Lakes Erie and Ontario, and the St. Lawrence River; touch and encircle the finger lakes of the central part of the State and pass up, along and over the beautiful valleys and mountains of the southern tier.

"New York State should lead the world in highway construction. Its people have voted to expend $100,000,000, the largest amount of money in the world available for this purpose, and the Empire State of the Union should and must lead all others in the good-roads movement."

The Note on Water Rates published in the Engineering Record of July 26, page 96, referred erroneously to the city of Los Angeles. The reference should have been to San Diego.

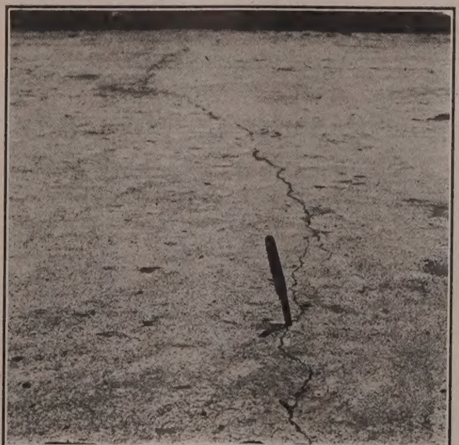
Typical California Concrete Road near Roseville

In the 9 miles of oiled concrete road which the California Highway Commission is building between Roseville and Lincoln as a portion of main route 3 between Sacramento and Oregon, via Redding, of 344 miles total length, no expansion joints as such are constructed. Examination of a portion of the road in June shortly after construction by a representative of the Engineering Record disclosed cracks at intervals varying from 6 to 75 ft. in a paved distance of 1120 ft., with an average of 28 ft. between cracks. As the concrete will never have any expansion greater than when laid, only contraction difficulties are anticipated, and the engineers are of the opinion the oil covering will amply seal these minute cracks and any others that may appear as cool weather sets in.

Two coats of oil, ½ gal. per square yard, containing 95 per cent or more of asphalt, will be applied by a power sprayer under about 200-lb. pressure. Broken stone screenings will then be spread sufficient to cover and take up the oil.

Typical of some 100 miles of concrete road under construction, the Roseville road is 15 ft. wide, 4 in. thick, of 1 : 2½ : 5 mixture, and is laid on a base rolled with a 10-ton Monarch roller. A crown of ⅜ in. to the foot is given the road, and the subgrade is rolled parallel to the top, making the concrete uniformly 4 in. thick.

The concrete is watered for seven days from a 2-in. pipe laid either from Roseville or from Lincoln in a 4-mile stretch. Hose cocks are provided at every eighth pipe joint.



Largest Crack Barely Admits Knife

For a few hours after depositing the concrete is protected by canvas and then ½ to 2 in. of earth or sand from the side of the road is thrown on to hold the moisture. Some difficulty was encountered in getting water from Roseville on account of the low pressure, and at times it was necessary to let the water run all night and repump it during the daytime. When near enough Lincoln, toward which the work progressed, the pipe was relaid connecting to the Lincoln water mains, which gave 80-lb. pressure.

Sources of Materials

Broken stone from the Natomas Consolidated crushers is obtained from the nearest sidings on the line of the Southern Pacific Company, along which the road has been laid out, while sand is found in nearby dry stream beds. To expedite loading the wagons hauling broken stone, simple hopper bins shown in one of the illustrations are filled by men shoveling from the cars.

In distributing the material at the site of the work sand is dumped on one side, cement on the other and stone is disposed of on the rolled portion.

An average day's work is 550 ft., but a record of 750 ft. in eight hours has been made. Twelve teams are engaged in transporting stone, the maximum haul being 2½ miles. Fifteen men make up the gang attending the end-discharge traction 1-3-yd. Foote mixer, which is equipped with a gravity distributor. To protect the men from the intense heat an improvised galvanized-iron canopy is mounted over the mixer. One man sprinkles the work twice at night and five are employed in setting the side forms.

In nearly every case the counties have cooperated with the commission and built bridges at stream crossings on an approved design. On the Roseville section there is a slab-and-girder bridge of two 45-ft. spans 21 ft. wide between the concrete rails. The center pier rests on concrete piles built in place in holes bored in clay, as the creek was dry at the time of construction.

Burns, Clark & Da Roza were the contractors for this section. All work is done under the general direction of Mr. A. B. Fletcher, highway engineer for the California Highway Commission, and this special section comes in Division 3, of which Mr. W. S. Caruthers is division engineer.

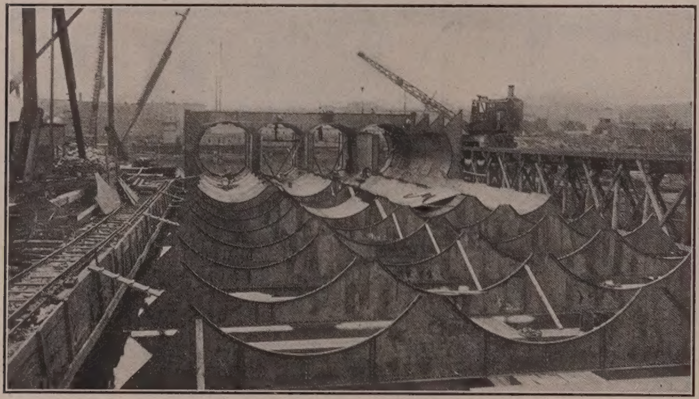
Building Harlem River Subway Tubes

The Harlem River tunnel on contract section 14 of the four-track Lexington Avenue Subway in New York is 1078 ft. long and consists of four concrete-lined flattened steel tubes, 19 ft. in diameter, inclosed in concrete and installed in a trench dredged in the river bottom at a maximum depth of about 60 ft. below high-water level, as described in the Engineering Record of Sept. 13, page 284, and on page 372 of this issue.

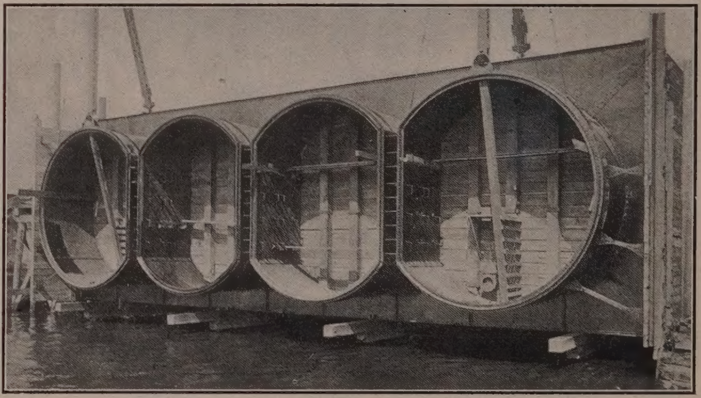
The steel tubes, 17 ft. apart on centers in the same horizontal plane, are rigidly joined together 2 ft. apart in the clear by 76 x 24½-ft. vertical transverse steel diaphragms, 15 ft. 7 in. apart, riveted to their exterior surfaces. There are five four-tube sections of nearly equal lengths, the intermediate ones having a uniform length of 220 ft., all of which are assembled and riveted up complete at the contractor's yards near the tunnel site.

Assembling and Riveting Steel

The structural steel is fabricated ready for riveting at the Ambridge plant of the American Bridge Company and is delivered by lighters to the contractor's yard on the Bronx side of the Harlem River about one-half mile from the tunnel site. Near there is a slip about 130 ft. wide and 250 ft. long, with two stiffleg derricks with 80-ft. booms installed on one side and on the opposite side an Ohio locomotive crane with a 50-ft. boom of 20 tons capacity located on a trestle that runs the full length of the slip at an elevation of 15 ft. above the water.

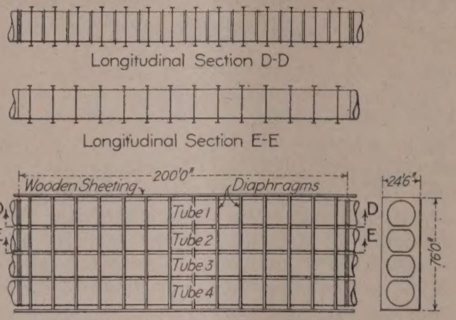


Assembling Transverse Diaphragms and Invert



Tube Section, with Bulkheads and Sheeting

The punched plates and angles are stored by the derricks, which are also used for assembling them and for delivering them to the traveling crane that commands about one-third of the area of the slip. Part of the diaphragm plates and angles are riveted up on shore and the lower sections of them are assembled on falsework in the slip and form cradles on which the steel tubes and the remainder of the diaphragms are erected and riveted. The entire operation for one tunnel section, until the steelwork is ready to remove and float, requires about four weeks. It involves the assembling of about 650 tons of steel, driving 80,000 ¾-in. rivets, and about 12,000 lin. ft. of calking, which is effected by a total force of about 65 men, including ten to fifteen riveting gangs with Chicago pneumatic hammers operated by one Chicago pneumatic compressor.



Steel Tube Tunnel Lining

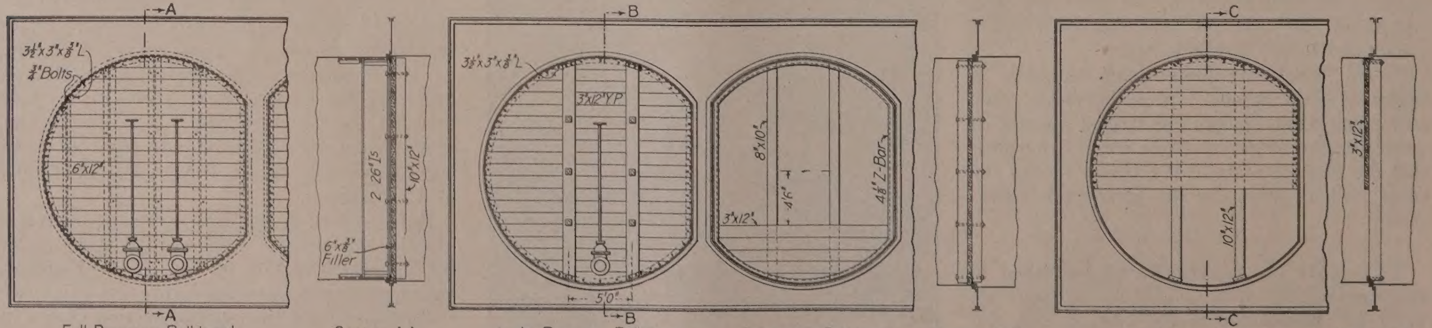
In order to exclude the water, give the tubes buoyancy for floating, and control their submersion, the ends of the tubes are fitted with temporary wooden bulkheads and intermediate semi-bulkheads are built across the upper parts of the two outside tubes to trap the air in case one end of the section should tend to plunge during the sinking. At the shore ends of the tunnel these bulkheads are made extra strong to resist the heavy unbalanced pressure when the interior of the tube is pumped out. The other end bulkheads are only required for use in sinking and to resist the pressure head of about 5 ft. and are made much lighter, with 3-in. horizontal planks bearing against flange angles and inner surface of the tubes and against vertical wooden posts. In the heavy bulkheads planks 6 in. thick take bearing against very deep vertical I-beams. Both light and heavy bulkheads have their joints calked with oakum and through their lower parts have inlet pipes controlled by 12-in. valves.

As soon as sinking is begun water is freely admitted to the tubes, so that they do not require complete end bulkheads but only have the lower parts of the ends closed by flash boards. The semi-bulkheads or air curtains intermediate between the end bulkheads serve only to maintain steadiness and uniformity of descent of both ends of the long tubes during sinking and are made of 3-in. planks with calked joints.

Removing Steel Tubes from Falsework

The tubes are assembled and riveted complete, with the lower flanges of their transverse diaphragms bearing on four equidistant lines of longitudinal stringers about 1 ft. above high-water level. These stringers are supported by four longitudinal rows of piles 15 ft. 7½ in. apart, with clearance of 18 ft. between the longitudinal rows of piling. In each of these spaces between pile rows there are floated at low tide three wooden scows 14 ft. wide and 80 ft. long, ballasted with enough rock to nearly overcome the buoyancy of the timber, which have an excess buoyancy due to displacement of 100 tons each. The weight of the steelwork, bulkheads, and timber sheathing on the outer faces of the diaphragms amounts to about 800 tons, so that the nine scows have a combined lifting capacity 100 tons greater than the weight of the tunnel section and easily lift it free of the falsework with a rising tide.

The tubes are towed out of the dock to a more convenient place and fitted with the necessary valves, pipes and buoyancy cylinders. The scows are scuttled through inlet valves controlled from above, and the buoyancy which they possess in excess of the rock



Full Pressure Bulkhead — Section A-A — Light Pressure Bulkhead — Segmental Bulkhead — Section B-B — Interior Semi Bulkhead — Section C-C

Part Elevation of End of Steel Tunnel-Lining Tubes, with Temporary Valves and Wooden Bulkheads ballast is so small that they can easily be pulled free of the tunnel section floating by its own buoyancy. The scows are then returned at convenience to the next tunnel section which is being erected on the falsework.

The work is executed under the direction of the Public Service Commission, of which Mr. Alfred Craven is chief engineer and Mr. Robert Ridgway engineer of subway construction. The Arthur McMullen & Hoff Company is the general contractor, and Mr. R. N. Melvin is superintendent in charge.

Book Reviews

The Society for the Promotion of Engineering Education has issued Part II of Volume 20 of its "Proceedings." In addition to business affairs and statistics of the society there are contained fifty papers by engineering educators. All branches of engineering instruction are dealt with; the civil engineer, however, will not be directly concerned with some of the papers. Among the numerous papers which should interest him are "Live Questions in Technical Education," by Prof. W. G. Raymond; articles by Prof. W. T. Magruder giving the results of a tour of investigation of laboratories, and a number of other papers pertaining to materials-testing, hydraulic and mechanical laboratories. (Ithaca, N. Y., Office of the Secretary, Cornell University. $1.25 net.)

"Coast Erosion and Protection," by Ernest R. Matthews, borough engineer of Bridlington, England, is a 143-page résumé of the erosion and accretion that are taking place along the coasts of Great Britain and Ireland. This phase of maritime engineering is of special interest to the residents of those islands, but the conclusions drawn have an application to the shifting coast-line of this country. Mr. Matthews calls attention to the full discussion of the design, maintenance and relative costs of the important types of sea defenses. Experiments to determine the action of sea water, as well as fresh water, on concrete form a useful feature of the book, which is well illustrated throughout. (Philadelphia, J. B. Lippincott Company. $3.50 net.)

Engineering Thermodynamics. By Prof. Charles Edward Lucke, Ph.D. Cloth, 6 x 9; 1188 pages; 328 figures. New York, McGraw-Hill Book Company. $8 net.

The titles of the six chapters without their several subdivisions give but little idea of the scope of the book. The arrangement is considerably different from that of the usual work on thermodynamics in that the subject matter that usually appears at the front of the book is not given till the fourth and sixth chapters. In the first three chapters, the titles of which are "Work and Power," "Work of Compressors," and "Work of Piston Engines," there is no special reference to heat or to any special property of the fluid used in the compressors or engines. In these chapters the various expansion and compression curves are discussed and equations deduced for simple and multistage compressors, as well as for simple and multiple-expansion engines.

Chapter 4, on "Heat and Matter," treats of the qualitative and quantitative relations between heat content of substances and physical-chemical state, and includes such points as gas and vapor mixtures, absorption of gases by liquids and solids, heat transmission processes, etc.

Chapter 5 deals with fuels, furnaces, gas producers and steam boilers as far as heat production, transfer, etc., are concerned, but no description is given of apparatus or methods of use. The subdivisions of Chapter 6 show that it covers much of the work given in the usual text books on thermodynamics—general relations between heat and work, thermal efficiency of the steam engine, gas and compressed air engines, flow of expansive fluids, performance of mechanical refrigerating systems.

Although among the large number of problems given quite a number are worked out in detail, it would have added greatly to the value of the book if answers had been given to at least a portion of the unsolved problems.

To use the book intelligently the reader should have at least a fair knowledge of engine and boiler construction, as the treatment in the text is entirely general and no attempt is made to describe details of any form of apparatus. The man who uses the book for reference will be pleased when he sees the care with which all equations have been worked out, showing every detail of the process, but it is a question if such deductions are advantageous to the student who should learn to do these things for himself.

The book is of great value as a reference book in that the author has got together a large number of the principles used in everyday engineering work with such a collection of tables and curves of data as is seldom found in any one book. The more one reads the book the more one is impressed with the magnitude of the work and the immense amount of painstaking labor and energy that the author must have put into it.

Robert Fulton, Engineer and Artist—His Life and Works. By H. W. Dickinson, A. M. I. Mech. E., Assistant Keeper of the Science Museum, South Kensington. Cloth, 6 x 9; 333 pages; 23 illustrations. New York, John Lane Company. $3 net; postage, 20 cents.

In his brief preface the author states that the motive for writing this book is that, in his judgment, previous biographies have not been altogether fair and impartial. American biographers have claimed too much for Fulton, while English writers too often have dismissed him contemptuously. Mr. Dickinson has endeavored, therefore, by careful research to get at the important facts and to present them without bias. In this effort he has brought to light a great deal of new documentary material. Both the new and the old have been presented in a very readable style, without in any way neglecting the technical elements. That in the investigation by Mr. Dickinson Fulton's position as a pathfinder and a benefactor of the race has not suffered is evidenced by the appreciation of the man and his work toward the end of the book. The author states frankly that Fulton "ought to take a higher place than he has hitherto done in the roll of honor of the Anglo-Saxon race." As a thinker he gave evidence of a broad grasp of problems of world-wide interest and influence. As a worker he opened up new fields for human activity. "To mention as the offspring of Fulton's genius," Mr. Dickinson concludes, "only the first workable submarine torpedo boat, the first commercially practicable steam vessel, and the first steam-propelled warship is to entitle him to a place among the giants of the engineering profession."

While the title of the book would seem to indicate that a fair amount of space would be given to Fulton as an artist, this part of his career was so short that little is to be said about it. That he possessed no little ability as a painter, chiefly of portraits, seems evident. The inclusion of a chapter on the subject will serve at least to call attention to this little-known side of the great engineer.

It need hardly be said that the story of Fulton's work on his various projects—in England, France and the United States—is told at length. Of peculiar interest in view of our present-day ideas as to monopolies is the exclusive control exercised by Livingston and Fulton of all steamboat navigation on the waters of the State of New York.

Rules of Management. By William Lodge, President of the Lodge & Shipley Machine Tool Company. Cloth, 5¼ x 7¾; 139 pages; no illustrations. New York, McGraw-Hill Book Company. $2 net.

Coming from the president of a company as successful as Lodge & Shipley one would naturally expect in this book many valuable suggestions as to the methods of conducting a machine shop successfully. In this respect, whatever other shortcomings the work may possess, the reader will not be entirely disappointed. The wheat, however, lies hidden in much chaff.

The book is largely a reprint of instructions for the guidance of the officers and each department of the author's business. Beginning with the general manager, the functions of the executive are outlined, and even the duties of quite minor employees detailed. Each department is taken up separately and its duties and relations to other departments are defined. Many of the directions will be helpful to machine-shop executives, but the instructions, as a whole, are not a model of what "standard practice instructions" should be. The various points follow one another in haphazard fashion, without any apparent plan; superfluous matter is included in some chapters, while others are entirely inadequate. Of general instructions applying to all departments there are none. Consequently in chapters relating to specific departments will be found many directions equally applicable to other departments.

The chief value of the book consists in the possibility of indicating to executives not familiar with standard instructions the good that may be accomplished through their use. In other words, the book should be considered of an elementary character. Those who have followed the literature of management will be disappointed in it.

Experiments in Industrial Organization. By Edward Cadbury. Cloth, 5½ x 8; 296+xxi pages; no illustrations. New York, Longmans, Green & Company. $1.60 net.

Much has been written in recent years regarding the phases of works management founded on other considerations than mere money-making or mechanical efficiency. To this literature the work under consideration is a valuable addition. It tells the remarkable story of the success of welfare work of the most varied kind in the cocoa and chocolate works of Cadbury Brothers, Ltd., of Birmingham, England, employing more than six thousand persons. In many respects the schemes successfully worked out there go far beyond those which have been introduced in the most advanced (in this respect) industries in the United States.

The scope of the book is clearly indicated by the titles of the chapters: Selection of Employees, Education of Employees, Discipline, Provisions for Health and Safety, Methods of Remuneration, Organization (including explanation of the use of employees' committees), Recreative and Social Institutions, Industrial Conditions, Conclusions.

The selection of employees, as carried on in the Cadbury works, is far removed from the perfunctory performance that it usually is in the United States, though within the last five years much more attention has been given than formerly to get men and women into positions for which they are fitted.

Probably the most interesting chapter is that dealing with the education of the employees. Boys and girls entering the works agree to go to the evening continuation schools till they reach the age of 18 and at the same time to enter the physical-training classes. The courses are general in character, including English, arithmetic, history, geography, foreign languages, etc. There are in addition courses in the various trades used at the plant.

The welfare work in the way of medical care and the use of the convalescent home is fully described. The value of this feature of the work is indicated by the fact that 23,000 visits were made to the plant physicians during 1911.

Under "Methods of Remuneration" are described the pension and sick-benefit schemes, while under "Recreative and Social Institutions" are found information about a surprisingly large number of athletic, literary and social clubs run for and by the employees.

Throughout the book the various methods, schemes and activities are appraised and their influence on the workers and the industry noted. Their bearing on the labor problem is given particular attention.

Because of long and patient experimentation, the variety of schemes tried and in use, the experience and breadth of view of the author, and the careful presentation of results the book will not only be of value to executives directly concerned with industrial problems but should have a wide circulation among engineers generally and the public at large.

The Panama Gateway. By Joseph Bucklin Bishop, Secretary of the Isthmian Canal Commission. Cloth, 6 x 9; 459 pages; 65 halftone illustrations; one map. New York, Charles Scribner's Sons. $2.50 net.

It is not often that one can without reserve recommend a book in the words, "should be in the library of every engineer." Such can in truth be said of the book by Mr. Bishop. Those who have followed the remarkable series of articles which have appeared in this journal are thoroughly familiar with the technical details of that great work and understand the administration under which it has been conducted. But there are many phases of the canal work which, having been touched on only incidentally in the technical press, are likely to be forgotten in estimating the Panama achievement. All these things Mr. Bishop brings together, so that the canal story is complete, even from the time of the first suggestion of a canal.

The first part of the book is historical, dealing with the Spanish rule, the early projects of a waterway, the awakening of American interest and the first Panama railroad. The second part takes up the French effort and its failure, relating in detail the financing organization, work and failure under De Lesseps. Here, too, is told the story of the ravages of yellow fever in the French forces. Part 3 treats of the negotiations with the French company, with Colombia and with the Republic of Panama, culminating in American control of the Canal Zone.

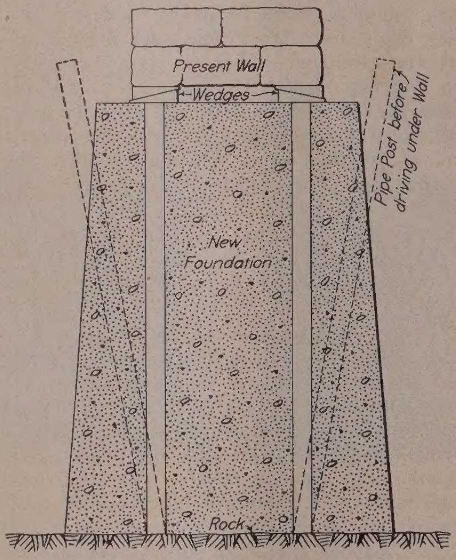
The fourth part is decidedly the most interesting. It deals with the construction period. The work of the various commissions is taken up, the defective organization of the first two pointed out, and the methods of the third (the present one) are reviewed in detail. The reports and Congressional action which brought about the adoption of the lock type of canal are given adequate attention. Particularly well put is the story of the battle with and victory over yellow fever, and of the conversion of the Zone from a pestilential to a healthful abode. Equally striking are the description and discussion of the form of administration of the Zone, in which due meed of praise is given to the central figure of the Panama work—Colonel Goethals. His famous court of justice is given its well-merited praise.

In general, highly technical matter and descriptions are avoided throughout, making a book of interest to the general reader, to whom, primarily, it is addressed. While much of the work contains facts still fresh in the minds of engineers, their collection into a handy volume at the present time, before the spirit of the leader and his workers has been forgotten, is a cause for congratulation.

Letters to the Editor

Underpinning without Needlebeams

Dear Sir: The writer witnessed what was to him a novel method of supporting a wall of a building while new foundation walls were being put in which went down to bed rock. The building in question was two stories high, with 12-in. brick walls supported on stone foundations 3 ft. 6 in. wide at the bottom. The soil was of a sandy nature, which soon showed its weakness when large cracks developed in the walls above within a year after completion.



Method of Underpinning Wall

The owners desired to build an additional story and determined to go down to rock with the foundations before starting the new work. Being limited for space, the contractor had to give up the scheme of using needlebeams. Moreover, it was feared that if piers were built anywhere near the present walls to support the needlebeams there might be a flow of the soil from the foundations which might bring on a sudden collapse.

After considerable debate, the following scheme was decided upon: Wrought-iron pipes of a thickness varying from 4½ to 6 in. in diameter were driven down beside the wall to rock which was found to exist from 8 to 10 ft. below the present foundations. They were started about a foot away from the wall and driven at an angle so that when the end reached the rock it was underneath the edge of the wall. The pipe was then filled with concrete cutoff so that it would come within about an inch of fitting underneath the wall. It was then brought into a perpendicular position by a jack so that it came underneath the wall. Steel plates, 8 x 8 in., of varying thickness were then wedged in on top of the pipe until it was judged a tight fit. Posts were then placed about 2 ft. apart on both sides of the wall and the earth between them was excavated to rock. The new concrete foundations inclosing the posts were then installed.

During the work constant watching was necessary when the plate wedges were being driven to prevent the lifting of the wall off one post by forcing too many wedge plates in another further along the wall. Before straightening the posts the earth back of them was gouged out with a 4-in. drill.

The idea is a new one to the writer and the contractors themselves do not remember ever having seen it done before. The buildings are located at the Medlicott Manufacturing Company's plant in Windsor Locks, and the contractor is the Watson Tryon Sons Company, of Hartford, Conn.

M. A. Connor,
Contracting Engineer,
Berlin Construction Company.
Berlin, Conn.

Correction in Pumping Costs

Dear Sir: An error was made in the original copy of the paper entitled "Comparative Economy of Producer Gas and Steam for Pumping Stations," published in abstract in the Engineering Record of Sept. 6. I refer to the cost of the plants per 1,000,000 gal. daily capacity. In the Delaware plant, page 262, second column, fifth line from bottom, $1925 per 1,000,000 gal. capacity per twenty-four hours should be $19,250, and on page 263, first column, third paragraph, next to last line $1,210 per 1,000,000 gal. per twenty-four hours should read $12,100.

Philadelphia. J. E. Gibson.

Specifications for Steel Highway Bridges

Dear Sir: In your issue of Sept. 6, page 255, you give a rather severe and, I think, sweeping criticism of Circular No. 100 of the U. S. Office of Public Roads on "Specifications for Steel Highway Bridges," which, in the main, was unwarranted.

One of the main purposes in issuing this publication was to show county officials not how to build steel bridges but rather the importance of calling in a competent engineer to supervise such work instead of relying on their own judgment and the representations of bridge companies. In the circular not fewer than forty statements are made showing the importance of employing an engineer to supervise bridge work.

You state that no specifications have greater authority than those of the American Railway Engineering Association, yet proceed to criticise sharply clauses concerning the unit stress for compression and tension and concerning the increased number of rivets for indirect splices taken directly from these specifications.

The Office of Public Roads prepared these specifications with a great deal of care, and it is only fair to mention here that we called into consultation an experienced bridge engineer, and we consider it ill-advised to criticise an effort which is distinctly in the right direction for minor and fancied defects. On the contrary, such efforts should be encouraged. We admit that there is room for improvement in a number of the standard-bridge specifications now in use. We shall be glad to adopt them when they appear.

L. W. Page,
Director, U. S. Office of Public Roads.
Washington, D. C.